

Generative Comics

A Computational Approach to Creating Comics Material

Doctoral Dissertation by

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UNIVERSITY OF GOTHENBURG

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Generative Comics: A Computational Approach to Creating Comics Material.

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This dissertation is heartily and solely dedicated to my parents who took the lead to Heaven before the completion of this research project.

Their prayers for me have resulted in this achievement, and without their inestimable love and care, eminent efforts and sacrifices, devoted upbringing and ardent nurturing, I would not have been where I am today and what I am today. After Almighty God, they are the only ones who love and give without expecting anything in return. Had it not been for their unflinching insistence and support, my dreams of excelling in education would have been nothing but mere dreams. I thank them with all my heart and soul as I do believe they are up there, listening, watching over me and sending me their blessings constantly.

To them, who had hands to give, but not to take; and hearts to love, but not to hate; I do dedicate this work, but still, the unspoken words remain greater than whatever had been, or to be said.

Malik Ahmad Nairat, Gothenburg 2021

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And last, but by no means least, I do extend both my apology and sincere thanks to all those whom I might have missed out.

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ABSTRACT

Digital storytelling can be employed as a tool that incorporates human creativity with technology. It synthesizes multimedia based elements to create engaging stories and compelling narratives. To this end, this research presents an approach that can be used as an assistant tool for comics artists. It focuses on generating comics-based narratives through a system that integrates three main components in the creation process, which are: *agent-based system* which generates raw narrative material based on the behavior of the system's agents, an *interactive evolution process* where the author participate in the creation process, and *comics generating engine* that creates final comics as outputs. The general scope of the research is to construct a generative system that has the ability to create comics and fictional characters.

The research utilizes the method of Research through Design (RtD) which favors evolution and iteration of the construction of the artifact based on trial and error to better solve complex design problems. Relevant aspects of computer science, visual arts, comics and storytelling have been combined together to form a unified research project that can answer the research questions: how can digital technology be employed in generating comics; how can it contribute to the creation of novel art forms; and how can it help artists in their creative practice.

Through a review of generative comics researches, four categories are identified: Unified Comics Generators which investigate methods for generating both the story structure and its visual comics-based representation, Comics Elements Generators which explore various techniques for generating or employing particular comics elements such as panels, splashes, speech bubbles, and others, Visual Representation Generators which rely on importing the content from other narrative sources such as video games, video streaming, or chatting conversations through social media, and Generative Comics Installations which produce and present comic stories in a form of exhibited installations by capturing and manipulating live pictures of the audience.

Research findings are discussed in terms of story characterization, the generated stories, and the comics visual representation. The constructed system showed high flexibility, scalability, competency, and capability that entitle it to be employed in various applications for different purposes.

Keywords: comics, multi-agent systems, interactive evolution, generative storytelling, digital comics.

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SAMMANFATTNING PÅ SVENSKA

Digitalt berättande kan bygga på verktyg som kombinerar mänsklig kreativitet och teknologi, och kombinera olika multimediaelement för att skapa engagerande berättelser. Avhandlingsarbetet presenterar ett nytt sätt att konstruera ett verktyg som assisterar serieskapare i deras arbete. Det fokuserar på att generera berättelser i serieform genom att integrera tre komponenter: ett agentbaserat system som genererar narrativt råmaterial med utgångspunkt i agenternas interaktion, en process för interaktiv evolution där serieskaparen tar aktiv del, och ett generativt maskineri som skapar de slutliga serierna och deras visuella representation. Arbetets övergripande mål är att skapa ett generativt system som kan skapa både serier och fiktiva karaktärer.

Arbetet i avhandlingen är baserat på metoder för Research through Design (RtD), eller forskning genom design, som innebär iteration och evolution av artefakter för att systematiskt lösa komplexa designuppgifter. Olika relevanta aspekter från datavetenskap, konst, serier och berättande har kombinerats för att skapa ett enhetligt forskningsprojekt som kan svara på forskningsfrågorna: Hur kan digital teknik användas för att generera serier? Hur kan tekniken bidra till utvecklingen av nya konstformer? Och hur kan tekniken hjälpa konstnärer i deras kreativa utövande?

Genom en översikt av forskningen kring serier och generativa algoritmer har fyra forskningskategorier identifierats: Unified Comics Generators där både berättelsens struktur och visuella representation som serier genereras samtidigt, Comic Element Generators som utnyttjar olika tekniker för att skapa eller använda delement i serier som t ex paneler, splashsidor och pratbubblor, Visual Representation Generators som importerar innehåll från andra källor som videospel, videoströmmar eller chat-konversationer i sociala medier, och Generative Comics Installations som utvecklar serier som installationer genom att använda levande bilder av besökarna.

Forskningsresultaten beskrivs och diskuteras både i termer av karakterisering i berättelser, egenskaperna hos de berättelser som skapas av systemet och deras visuella representation som serier. Systemet som skapats som del av avhandlingsarbetet uppvisar flexibilitet, skalbarhet och andra egenskaper som gör att det kan användas i olika tillämpningar.

Nyckelord: serier, multiagentsystem, interaktiv evolution, generativa berättelser, digitala serier.

LIST OF PAPERS

This thesis is based on the following papers:

1. Nairat, M., Dahlstedt, P., & Nordahl, M. G. Character evolution approach to generative storytelling.
2011 IEEE Congress of Evolutionary Computation (CEC), pp. 1258-1263, 2011.
2. Nairat, M., Dahlstedt, P., & Nordahl, M. G. Story Characterization Using Interactive Evolution in a Multi-Agent System.
EvoMUSART 2013; International Conference on Evolutionary and Biologically Inspired Music and Art, pp. 168-179, 2013.
3. Nairat, M., Dahlstedt, P., & Nordahl, M. G. An interactive approach to story characterization.
2013 IEEE Symposium on Computational Intelligence for Creativity and Affective Computing (CICAC), pp. 56-62, 2013.
4. Nairat, M., Nordahl, M. G., & Dahlstedt, P., Generative Comics: Character Evolution Approach for Creating Fictional Comics.
Published in: Digital Creativity Journal, Vol. 31, No. 4, pp. 284-301, September 2020.
5. Nairat, M., Dahlstedt, P. Generative Comics: Introduction and Analysis.
Published in: International Journal of Comic Arts (IJOCA), Vol. 21, No. 2, Fall/Winter 2019, pp. 268-294.
6. Nairat, M. Character in Fiction: Importance & Development Techniques.
Submitted to Popular Culture Studies Journal, 2021.

DISTRIBUTION OF WORK

Paper 1

The third author provided the framework and the study approach, the first author planned the study, conducted the research, wrote the code, executed the experiments & simulations, and analyzed the data in cooperation with the other two authors. The manuscript was written by the first author, reviewed and edited by the third author, while the second author contributed to the script review and provided technical assistance and feedback, as he presented the paper in the conference instead of the first author due to travel and visa easiness on his part.

Paper 2

This paper is based on findings from paper 1. The first author conducted the main analysis and compilation of the results assisted by the second and third authors. The paper was written by the 1st author, reviewed and edited by the third author, while the second author reviewed the script and provided feedback. The paper was presented in the conference by the first author.

Paper 3

The first author planned the study, carried out the coding, experiments and simulation, and wrote the paper. The other two authors reviewed and edited the manuscript, while all authors contributed in the analysis and compilation of the results. The paper was presented in the conference by the second author instead of the first one due to travel and visa obstacles.

Paper 4

The research, coding, experiments and simulations were carried out by the first author who wrote the paper in cooperation with the third author. The third author provided significant review and editing of the text in addition to data analysis with the first author. The second author contributed to the feedback and review of the text.

Paper 5

The first author planned the study, conducted the research, analyzed the data and wrote the manuscript. The second author reviewed the text, contributed to the analysis of the data and provided feedback.

Paper 6

The first author planned the study, conducted the research, wrote, reviewed and published the paper.

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ABBREVIATIONS

RtD	Research Through Design
GA	Generative Art
GAN	Generative Adversary Networks
MOGs	Multiplayer Online Games
IVAs	Intelligent Virtual Agents
FFM	Five-factor Personality Traits Model
CSDL	Comic Strip Description Language
EA	Evolutionary Algorithms

DISSERTATION OUTLINE

Chapter (1) Introduction

Digital technology has transformed every aspect of our life; however, it is unlikely that it can entirely replace human creativity, but they can be exquisitely integrated to produce distinctive artworks. To this end, this research is conducted to propose an approach that can be employed as an aiding tool for artists to create compelling comics stories. The general scope of the research is storytelling art coupled with the use of images and comics that represent the characters of the narrative being told, and its main purpose is to construct a generative system that has the ability to create fictional characters for comics narratives.

Chapter (2) Theoretical Foundation

Digital storytelling has emerged as a new art form that incorporates the power of human creativity with the pervasive and powerful nature of digital media and computer science. It synthesizes multimedia based-elements such as animated and still images, video, audio recordings of voice and music, and text to create engaging comics stories and compelling narratives. The peculiar features of digital storytelling such as interactivity, emergence and immersion enable it to generate a wide variety of non-predefined stories that emerge from the interactions between the user and the system. This new art form is called generative storytelling, in which three approaches are usually used by authors and artists to generate narratives, which are plot-based, character/agent-based, and hybrid approaches.

Chapter (3) An Approach to Generative Comics: Literature Review

Through a quick review of the works produced in the field of generative comics, four categories are identified: Unified Comics Generators, Comics Elements Generators, Visual Representation Generators, and Generative Comics Installations. In this research, the presented approach relies on integrating three layers of processing in the generative system, which are: character-based environment that generates storylines based on the interactions between the agents' environment and their behavior, interactive evolutionary process which procreates new generations of characters based on their parents' personalities and behavior, and comics generative system that converts the generated story material to comic strips.

Chapter (4) Summary of the Studies

I. Interactive Approach for Generating Story Structures:

The study proposes an approach for generating narrative structure by combining two procedural methods: multi-agent system and interactive genetic algorithms. The structure is intended to provide the artist with a narrative skeleton that can be refined and developed into a final artwork.

II. Character Development:

This study is a part of the theoretical foundation, and is intended to establish a knowledge base about the nature and importance of character in literary narratives and provide better understanding of story characterization.

III. Interactive Method for Story Characterization:

This study investigates the possibilities of expanding the system to be used in designing and building characters; thus, the emphasis here is on the characterization process rather than on the story structure.

IV. Generating Comics:

This study proposes a framework to create comic stories based on the methods described in previous studies. The generative system in this framework was developed and updated to provide extra and more efficient functionalities and controlling tools for generating final comics stories. The focus of the study is on visual storytelling through the medium of comics, and the findings show that such methods can be useful and practical in creating interesting artworks that can be considered either as final artworks or works-in-motion to be manually developed later on by the artist himself.

V. Analysis and Overview of Generative Comics:

This study provides an overview and analysis of the conducted researches and works in generative comics. It identifies four different categories of generative comics, which are: integrated comic generator systems, comics' elements generators, visual representation generators, and generative comics installations.

Chapter (5): Discussion

The findings of the designed system are discussed in terms of characterization and the personalities of the generated characters, the generated stories as a result of characters' behavior, and the visual representation of the generated comics story. In sum, the constructed system showed high flexibility that entitles it to be used in various ways for different applications. The potential value and efficacy of this approach is extremely

wide due to its flexibility, scalability, competency, and capability to be employed in various applications for different purposes.

Chapter (6) Conclusion

In the current digital era, our dependence on technology is increasing on a daily basis, leading to new lifestyles and calling for new revisions and adaptations in almost every aspect of life. In the case of creative works and visual arts, practitioners have no option but to continually adapt their styles and techniques to accommodate this era. In the last few decades, generative art and comics started to attract the interest of researchers and artists as two promising creative fields that can be employed as representation tools in the various fields of education, training, entertainment, and communication. This research proposes an approach through which the strengths of generative systems and comics are integrated to form an amalgamation that aims to create unique forms of storytelling and comics narratives. It also shows how to build a framework that supports human creativity in fictional characterization and creates comics through a process of interaction with the user. It furthermore focuses on studying simple agents that have plain structure in terms of its internal state and personality, and argues that they are particularly relevant to the creation of cartoons and comic strips, where simplified and exaggerated actions and personalities are commonly used for illustration purposes. Moreover, the constructed approach is multifaceted and shows high flexibility that entitles it to be used for various purposes in different applications such as video games, gag cartoons and interactive storytelling.

1 INTRODUCTION

The advancement of digital technology has led to a growing interest in generative art. As a form of art and storytelling, comics can be a suitable form of representation for generative narrative. This thesis describes a generative framework for designing characters and creating comic strips through the use of an interactive system.

Since their inception on Earth, humans have always reshaped their life and extended their knowledge by virtue of innovations to improve their lifestyles. They have developed many tools and techniques to help them in their daily course of life and to increase the efficiency of performing tasks, and with results that might be impossible to gain without such tools. Science and technology have played an important role in this regard and will continue to generate new enhancers and innovations to support humans and improve their quality of life.

One of the most remarkable technological advances that have redefined the way we live and communicate is digital technology. It has given rise to new tools and procedures through which we perform and manage our daily tasks, and such tools improve our understanding of life, and enhance our planning for our future. It has transformed almost every aspect of modern life; travel, work, shopping, entertainment, mass media and communications are just some of the areas that have been revolutionized and improved by this technology. It is now uncommon to find an electronic device or piece of machinery that doesn't incorporate digital technology in one way or another. With the rise of social media apps for example, we are now able to talk to any person in any corner of the earth. We can do everything in the blink of an eye, we do not need to leave our house to get food, to watch a movie, to talk to a friend or get our groceries delivered; we already have apps for all these services, and this allows us to lead a more convenient life. Knowledge has become less asymmetric than in the past, when only certain people had access to an accumulation of knowledge, while others had no access to it. Now everyone has access to all kinds of knowledge at any time, pace, or place.

The possibilities and ways of using and implementing technological advances are unlimited and subjective to the developers' goals and users' needs. But while technology can be supportive of humans in many cases, it can cause problematic scenarios in others, such as replacing humans with machines or robots in the workplace, which might create social and financial problems for many people. Thus, the vital issue is not how to acquire technological

advances, but how to use them; it is an issue of usage and manner rather than possession. However, we are still far from the time in which technology can replace human creativity and inspiration in the fields where creativity is a central requirement such as visual arts, music creation, strategic planning, industrial design, storytelling, or comics.

Creativity is the synthesis of human inspiration, imagination, and improvisation, which computers and machines still fail to replace or even mimic [1]. Ultimately, a computer or a machine may still lack the imagination or creativity to dream up a vision for the future, as it lacks the emotional competence that a human being has. Hence, creativity may remain and continue to be the human skill that cannot be replaced by artificial means. This concept of human unique ability has been adopted in this research to create comics through the interaction between the user and the machine.

The Oxford dictionary [2] defines imagination as “*the action of forming new ideas, images or concepts of external objects not present to the senses or never before wholly perceived in reality.*” Creativity, on the other hand is defined as “*the use of imagination or original ideas to create something.*” Thus, imagination is “*the beginning of creation*”, as described by George Bernard Shaw [3], and “*Man’s power over nature*” as described by Wallace Stevens [4]. Its importance for reality can be summarized by the immortal words of the Irish author Michael Scott [5] when he said: “*Imagination is more important than knowledge. For knowledge is limited to all we know and understand, while imagination embraces the entire world, and all there ever will be to know and understand.*”

Without imagination there is no creation; it is our imaginative ability that allows us to dream and think differently and transform these thoughts into reality. Imagination is the source of every form of human achievement and the power through which humans managed to improve their wellbeing and develop their social life from constant migration to settlement, and from hunting tribes to organized societies and civilized communities [6]. As mentioned above, imagination is the stimulus and essence of creativity; before it comes into existence, any creative idea is already there in our inner mind in the form of imagination. When we nurture this imaginative idea with our inner instinct for evolution, and embrace it with our love, hope or enthusiasm, we immediately see the dawn of inspiration, and inside inspiration lies creativity [7]. Without imagination we cannot inspire others since we cannot be inspired ourselves. It is only when imagination becomes

completely and unreservedly united with inspiration, that we see and realize creative and unique achievements in our life.

Nevertheless, no one can deny the positive impacts of digital technology on human creativity through its facilitation of the conditions necessary for the development and implementation of new ideas in various fields of knowledge. In the creative fields of visual arts, comic strips, and storytelling in particular, there is almost a consensus among scholars and practitioners that digital technology has improved these domains and fostered the evolution and enhancement of their practicing styles and creation tools [8].

In short, the synthesis between art and digital technology has become stronger than it has ever been, as it has produced various effective tools that have helped artists in their conduct of the creative process and their quest for distinctive artworks through improving their precision, enhancing their expression, speeding up their processing time, facilitating their idea and topic research, and disseminating their artworks into the whole world. Through a quick review of contemporary art in both its visual and written forms, one can see that digital technology and computer science have indeed redefined art in terms of its creation techniques, representation media, and daily practices. The developments in these two fields have furnished artists with a wide array of options and a constellation of enormous technological capabilities and techniques, which in turn, have expanded their horizons of thinking and opened a gateway to creativity that is replete with an enormous variety of stunning tools and techniques. Hence, this research contributes to this development by providing and describing an approach to generate narrative in the form of comic strips and employs this approach in an interactive generative system that integrates human creativity with technology.

1.1 RESEARCH SCOPE & MOTIVATION

Artists achieve their mission through different media such as visual arts, music, sculptures, and multimedia to name a few. Their effect on our individual psyches and emotions is quite difficult to quantify. Art and artists could be argued to have the right to be supported by scholars and academic institutions to provide them with all the possibilities, choices, inventions and tools that might help them in their mission to inspire and refine the present, and shape the future of their society and culture.

Inspired by these concepts, and motivated by this goal, this research is conducted to contribute in helping artists to accomplish their tasks and represent their current era through acquainting them with experimenting tools that have the ability to support artists' creativity. This could expand their horizon of imagination and differentiate their stimuli for inspiration, as new tools can provide them with multiple options for the topic in hand to choose from as a raw material for further enhancement and development.

The research of the thesis adopts comics as a form of narrative representation, as comics integrate unique qualities that make them a suitable form of representation for generative storytelling. This concept is discussed in detail in section 1.3.

Regardless of the type of representation by which the story is being told, there are basic elements and formal components that constitute the form and the structure of any creative story. One of the most important elements is story characterization, i.e., the process and technique of designing, creating, and representing the story characters. It should be carefully handled and precisely represented by the artist since it is central to the success of any story, and characters are the driving force that moves the story ahead. Traditionally, building characters relies completely on the author's cognitive skills and imaginative abilities; he usually creates characters and develops them from scratch through a step-by-step technique, which is a complex, long and difficult process; thus, authors always seek any additional tools and techniques to support them in the characterization process.

Henceforth, this research is carried out with a main focus on two related issues. The first is that digital technology can actually be used as an aiding medium to support artists and authors in their creation of artworks, and the second is that human creativity is essential for artistic work. It tries to clarify these issues by integrating digital technology and human creativity to generate visual narratives in the form of comic strips. An approach to the generation of comics-based drama is described and implemented in a system that integrates three main components in the creation process: an agent-based system which is responsible for generating raw narrative material based on the behavior of the system's agents and the interactions between them, an interactive evolution process where the artist/author utilizes his imagination to participate in the generation process, and a comics generating engine that creates comic strips as final output.

The thesis argues that the integration between modern technological tools and human creativity in generating artworks has the ability to overcome the

weakness of technology as a creative device, and the limited ability of artists to explore a broad range of possibilities, as it can simplify and accelerate the artwork creation process. It proposes a method and presents an approach that can be employed as an assistant tool for authors/artists in their process of creating fictional comics stories and characters. The presented approach focuses on characterization as one of the essential elements that constitute narratives. Its general scope is storytelling art coupled with the use of images and comics that represent the characters of the narrative being told, and its main purpose is to construct a generative system that has the ability to create fictive characters for comics narratives. An interactive agent-based system is built to test the theory presented in this research. The system can be used to build story characters through integrating an interactive evolutionary method in a multi-agent framework, where the stories are generated from the agents' behavior and their interaction with each other in a virtual environment and presented in the form of comic stories as the output of the system.

This approach provides the ability to free the author/artist from constrained ways of thinking and a restricted array of choices. Instead of building characters from scratch, the system creates them with different personalities to choose from, and with the capacity to be modified, improved, and developed by the artist.

In summary, this research contributes to the world of contemporary art in two parallel ways: offering artists a tool that has the ability to help them in their search for creative ideas, and presenting a new and different technique for creating fictive characters and narratives. After all, art itself is a call for innovation.

1.2 RESEARCH QUESTIONS AND METHODOLOGY

The increasing developments in computer technology have made any distinction between the various academic disciplines seem less meaningful than ever before. Computer science and digital technology are now strongly present in almost any type of academic research. This qualitative, multidisciplinary research study can be approached in light of this fact. It tries to explore the boundaries of multidisciplinary creativity; namely, to investigate the possibilities and capabilities of digital technology, computer science and visual arts when combined with each other to produce an artistic project. To achieve this, a practice-led research method is employed which concentrates on interactive and generative comic stories, where the professional practices of these arts plays an instrumental part in the inquiry process. Related research methods such as research through design (RtD) are believed to be the most suitable for this project since *“creative work in itself is a form of research and generates detectable research outputs”* [9]. Furthermore, creative practice itself generates innovations that can become crucial contributors to the overall body of knowledge.

In this multidisciplinary research, relevant aspects of computer science, visual arts, generative comics and interactive storytelling have been combined and linked together to design and create a unified research project. Each discipline provides some piece of its practice and theory that is compatible with or mutually beneficial to the other disciplines without any change in the way the discipline itself fundamentally works. The final output of this integration will provide an answer to the following research questions:

- How can one employ computing generative methods in creating tools for comics’ artists that can simplify their tasks and enrich their creativity?
- How can one use such methods as co-authors in creating new form of comics?
- How can one integrate between human creativity and the abilities of machines in generating comics through an interactive process between the user and the machine?

Henceforth, the methodology of this research is divided into two parts: an applied part and a qualitative-based theoretical part. The primary research method follows the method of Research through Design (RtD) which was

coined by Christopher Frayling in 1993 as a proposal to differentiate between different types of design research, and by Anne Burdick in her essays on the same topic [10]. Frayling describes RtD as: *“Taking design as a particular way of thinking, and a particular approach to knowledge, which helps you to understand certain things that are outside design.”* [11]

Thus, RtD considers the design process as a way of research activity to explore and examine the tools of design thinking and implementation [12]. [13] defines RtD as: *“an approach to scientific inquiry that takes advantage of the unique insights gained through design practice to provide a better understanding of complex and future-oriented issues in the design field.”* [12] describes it as: *“..constituted by the design process itself, including materials research, development work, and the critical act of recording and communicating the steps, experiments, and iterations of design.”* Research through design relies on experimentation as a main component to draw conclusions and validate ideas, and experimentation can lead to discoveries, innovations, and creativity [14].

RtD is usually combined with a secondary research design using methods such as contextual inquiry, observation, and an experience sampling method, then reframing the problem to arrive at the right solution through processes of ideation, experimentation, and critique [12]. RtD favors constant evolution and iteration of the construction of the artifact based on trial and error to better solve complex design problems [13]. It differs from research-driven art or design in that the goal in research-driven art and design is the artwork itself and not the knowledge or understanding, while in RtD the goal is the knowledge and understanding that emerge from the designing and making of an artifact [11] [13].

Henceforth, conducting this research requires building an artifact that can be used as a tool of exploration, experimentation, and validation of the proposed approach; thus, a computerized system was created and developed in stages and employs concepts and results obtained from the theoretical research for the creation process of characters and stories through conducting a series of simulations and experiments. The development of the system, including its graphical user interface, relied on employing methods of design such as cognitive walkthrough which evaluates the resemblance of the system cues and prompts to how people cognitively process and anticipate tasks and experience prototyping [15], [12].

The simulations carried out focus on particular aspects of the story creation. While some studies investigate story characterization, others focus on

creating story raw material in order to be developed manually by the artist. A complete description of these studies is presented in chapter 4.

The system structure consists of three layers; an agent-based environment where stories are generated from the interactions between the agents, an interactive evolutionary process that allows the artist/author to observe the agents' behavior and intervene in that behavior if necessary and evolve the agents that appear interesting enough, and finally, a comic story generating process, which provides the artist with all the tools she needs to generate comic strips.

The system was designed and built based on the results obtained from a qualitative-based research process that aims to gather insights of particular aspects of other related fields of the study which are relevant to the methods and goals of the proposed approach. The research links those fields of study together to compose a unified research project.

Comics, fictional narratives, story characterization, multi-agent systems, and evolutionary algorithms form the knowledge foundation of this research, as it is important to understand relevant aspects of every field that contribute to the employment of the proposed approach. For this purpose, several research techniques have been modified and adapted in order to search and analyze the space of information of every related discipline and construct a unified knowledge base as a foundation for the primary research. These tools include literature reviews, concept mapping and brainstorm graphic organizers. Such techniques help in virtually understanding the knowledge and the relationships between its contents, providing fluency of thinking, and exploring new concepts and ideas [16].

The investigations of the first four papers were conducted with a basis in an RtD research methodology as they investigate different aspects of designing a storytelling system. The other two papers made use of a qualitative research process, as the goal is to construct a knowledge background relevant to the research approach, such as an analysis and review of how other researchers employed generative methods in creating comics (paper 5), and a study of the nature and importance of story characters and characterization in storytelling (paper 6).

1.3 WHY COMICS?

This section discusses the qualities of comics that are relevant to generative methods and the reason behind choosing comics as a representation medium in this research.

Comic books as visual art and narrative medium have been in existence since the end of the 19th century; nevertheless, they have always been viewed as childish, humorous, trivial and fantasy-based works that are crowded with coarse language and silly jokes, and thus, not worthy of academic and critical attention. Meanwhile, the last two decades have witnessed a surge in comics' researches and studies, with an increasing level of literary and social acceptance and acclaim, and with a large number of academic conferences, papers, and journals being presented each year. The reason behind this increasing popularity and academic interest in comics is not only because it offers a form of entertainment and a tool of education for both young and old, but also because it has the ability to offer a source of intellectual stimulation, creative inspiration, cognitive motivation and social hope, as it has the tendency to reflect the cultural, social, economic, political, and educational landscape of any generation. For kids, comic strips are a terrific way to introduce them to storytelling and develop their visual literacy; for younger readers, comic superheroes are the perennial defenders of good against the forces of evil, and the old comic books provide a form of escapism from today's daily stressors.

Building on these observations and others mentioned earlier, comics are used as the main tool of representation for the stories generated through this approach. This choice was not taken arbitrarily, but rather due to the features and characteristics of comics that accommodate with generative methods to storytelling. Besides, comics represent a unique nexus of distinctive features and qualities that distinguish them from any other medium of storytelling, and accord with the peculiar features of digital storytelling such as interactivity, capacity, nonlinearity, and spatiality. According to Duncan and Smith [17], the diversity in creative formats, genres, voices, content, and word-and-image combinations that "*inspires truly new forms*" makes comics particularly suited to push the boundaries of multimodal storytelling.

Thus, we argue that comics are the most suitable medium of representation for the output of generative storytelling. This, however, does not mean that other media are not applicable, but it means that comics have the potential to display the generated stories in more expressive and exquisite ways.

Therefore, a good understanding of the nature and characteristics of the comics medium is significant for understanding the proposed approach.

1.3.1 COMICS FEATURES AND CHARACTERISTICS

As an artistic narrative medium on its own merits, the comics medium uses text and images through panels placed in sequence to tell a story, deliver a message, or highlight a concept. Scott McCloud [18] defines it as *“juxtaposed pictorial and other images in deliberate sequence, intended to convey information and/or to produce an aesthetic response in the viewer.”*. Hayman and Pratt [19] define it as: *“a sequence of discrete, juxtaposed pictures that comprise a narrative, either in their own right or when combined with text.”*. Will Eisner [20] calls it as *“sequential art”* and describes it as *“the arrangement of pictures or images and words to narrate a story or dramatize an idea”*. R. C. Harvey [21] defines it as *“pictorial narratives or expositions in which words (often lettered into the picture area within speech balloons) usually contribute to the meaning of the pictures and vice versa”*.

In short, comics have been given different definitions by different authors and theorists. Nonetheless, there is sufficient similarity among these definitions to permit a rough scheme of classification that deals with comics as a narrative medium which entails an orientation, complication and resolution. To put it differently, comics like any other narrative medium, needs a plot, a structured narration of events, and characters who drive the action, pose the problem and resolve it. According to Duncan and Smith [17], the narrative structure of comics fits in one of three categories: *simple narrative* where the plot structure is based on a single problem and its resolution such as children comic books, *complex narrative* with subplots and complex set of settings and characters, and *abstract* or *non-narrative* structure in which the focus is not on telling the story but on expressing emotions or exhibiting aesthetic properties¹. In this structure, viewers are involved as co-authors and rely on the repetition of images and sequences to construct visual interest and evoke cognitive perception rather than employing sequences to follow a plot line [22]. This makes the latter category more applicable to autonomous generative systems and interactive narratives than the other two structure categories.

¹ Comics’ scholars Daniel Stein and Jan-Noël Thon argues that the concept of *“non-narrative comics”* is an underestimation of the reader’s role in the perception of the graphic narrative; thus, even unrelated images can produce a simple narrative in the reader’s perception [191].

Other intrinsic characteristics of the comics medium that entitle it to be the perfect representation tool for generative art and interactive storytelling are briefly discussed in the following sections.

1.3.1.1 HYBRID NATURE

Will Eisner [20] and Scott McCloud [18] have an important position in defining comics as a distinct medium that combines sequential images with verbal text to communicate a story. Eisner specifies that in comics, writing and image-making “*are irrevocably interwoven*” [20]. Harvey [21], sees comics as “*a blending of visual and verbal content*” or, more specifically, the “*static blending of word and picture for narrative purpose.*” He, furthermore, considers “*the essential characteristic of comics – the thing that distinguishes it from other kinds of pictorial narratives – is the incorporation of the verbal content*”; he then extends to say “*in my view, comics consist of pictorial narratives or expositions in which words (often lettered into the picture area within speech balloons) usually contribute to the meaning of the pictures*”. Dale Jacobs [23] states that “*what makes [comics] distinct from other kinds of texts is their blending of images and words, a combination of sequential art and text to create meaning, including narrative meaning, for the audience*”.

As stated above, the hybrid nature of word-image interactions is one of the most important features of comics; the scholar Kai Mikkonen [24] states that this interaction provides the reader with clues about characters and story elements. Scholar Maaheen Ahmad [25] specifies that the hybrid nature of comics allows them to be seen as both story and work of visual art, offering what is known as *double temporalité*, as the medium provokes the reader to pause reading in order to appreciate the art of images itself. Hatfield [26] argues that the interplay of images and words gives rise to a complex storytelling practice that is “*always characterized by a plurality of messages*”.

In summary, the combination of word-image features is undoubtedly one of the most typical features of comics when compared to other hybrid media, such as video or animation (moving picture-sound). When used together in a complementary relationship, the two have an unparalleled strength of expression and communication [18].

1.3.1.2 OPENNESS

In addition to providing visual pleasure to the reader, comics narratives provide a space for greater reader participation in constructing and reconstructing the story. This feature of “*conceptualization of interpretation*” or “*openness*” does not mean complete freedom of understanding, but rather a presence of multiple and interlinked interpretations that are channeled into the direction of the main themes and motives of the story. The main point behind openness in comics narratives is that different individuals arrive at different understandings of it, but as we may never know which interpretation is the correct one, we cannot have unlimited interpretations of it, but rather, multiple layers of meaning [25].

In his book *The Open Work*, Umberto Eco [27] defines an open artwork as an artwork in dynamic movement or process without a fixed ending or fixed meaning. To him, an open work has two constituents: a multiplicity of meanings and the participation of an audience. Thus, an open work is contingent, and its openness towards meaning determines its contingency.

Traditionally, creating openness in narrative works includes the use of ambiguous signs that need to be decoded by the reader, and terms that radically alter their referential function and profoundly eliminate any possibility for transmitting a univocal message [27]. In comics, the reader acts as a second author by putting the elements of the story and the entities of the comic medium together and constructing an interpretation of the sequenced panels in both linear and nonlinear manners; thus, the reading process becomes an interactive one between the story and the reader.

While openness does exist to some degree in other forms of narratives, the comics medium provides a great and unique contribution to the concept through its ability to present the story verbally and visually at the same time using a network of images, icons, figures, and words. Such a complex combination of visual signs, verbal terms, and multiple modes of expression can create movement, suggestiveness, unconventionality, and ambiguity that compel the reader to connect the pieces together and fill in the gaps for the perception of the story, while provoking different, yet linked interpretations of it [25].

According to Ahmad [25], infusing ambiguity can be attained through suggestiveness which evokes emotions and imagination through allusive rendition of stories and characters and self-reflexive elements, and unconventionality through indirect word-image relationships and transitions.

For instance, suggestiveness in comics is achieved through figuration and self-reflexive iconicity, as well as obscured rendering of characters. Such elements act as clues and messages that lead the reader through his journey to understand the story and construct his own interpretation of it.

Indirect word-image relationships and transitions between panels contribute to unconventionality [25]; for example, the gutter between the panels or “closure” according to Scott McCloud leads to constructing the whole from the parts [18].

1.3.1.3 SIMPLIFICATION AND STYLIZATION

A key feature of the comics medium is its visual language that emerges from its stylized and simple drawings, panels, and signs. Neil Cohn [28] argues that *“comics themselves are not a language but are written in visual languages the same way that novels or magazines are written in English. This makes comics potentially written in both a visual language and a written language.”* He further states that *“the sequential images used in comics constitute their own visual language that has its own vocabulary, grammar and syntax.”* According to him, stylized drawings, panels, and signs such as speech bubbles, motion lines, and stars constitute the *“visual vocabulary”* of this special language [28]. Will Eisner [20] compares gestures and graphic symbols to a visual vocabulary, while Scott McCloud [18] describes the properties governing the sequence of panels as its *“grammar.”*

As mentioned previously, comics stories are narrated through the use of word-image combinations, in which the scenes and characters are stylized and usually drawn by the artist. It is this stylization and simplification that give the story its own identity as a comic one and enhance its ability to convey a wide array of meanings, themes, and values to various types of audiences. Yet, as McCloud [18] reminds us, *“simple style does not necessitate simple story.”* He says that *“Cartooning is not just a way of drawing, it is a way of seeing! The ability of cartoons to focus our attention on an idea is I think an important part of their special power.”*

Focusing more on the aspect of simplification, McCloud [18] professes that by simplifying the images he draws, the artist will be able to amplify the meaning behind his artwork. He says that cartooning is *“...a form of amplification through simplification”* because *“When we abstract an image through cartooning, we are not so much eliminating details as we are focusing on specific details. By stripping down an image to its essential “meaning,” an artist can amplify that meaning in a way that realistic art*

cannot.”. McCloud’s concept model is that by making something such as a face (the example used in his book) simple, the more likely we are to connect mentally with that character’s face and associate ourselves with the character itself.

Besides simplification and stylization, comics drawing styles are normally exaggerated in certain topics with particular characters who have excessive distinguished qualities, such as superheroes (Superman, Ironman, Spiderman...) and mythological Greek Titans and Olympians (Oceanus, Cronus, Zeus, Poseidon...), where the muscle structure and body parts proportions are exaggerated to convey a sense of strength and power. Exaggeration is a very important facet of comics styles; unlike film or motion pictures, comics tell stories through static images, in which the realistic style of drawing the scenes’ compositions and the characters’ forms, actions and poses, tends to appear boring and weak. To overcome this side effect, exaggeration is used to amplify readers’ responses and feelings to story events and characters’ behavior (see paper 5 for more discussion about this topic).

The simplification, stylization, and exaggeration degrees in a given comics story depend on the genre of that story and the messages it conveys; Disney characters, for example, are more stylized and simplified than superheroes, mythological Gods, or crime story characters, as they target different audiences and intend to convey different messages.

1.3.1.4 ABSTRACTION

Unlike film and motion pictures, comics depend on a single human sense, which is sight, to present a whole world of experiences, meanings, and emotions [18]. It is the artistic style in comics that is responsible for the messages that can be delivered by the artist and conceived by the reader, and how that reader interprets and understands these messages in particular and the whole narrative in general. Creating abstract comic images that are not real-life looking is the main tool that comics employ to evoke the readers’ emotional responses. In such undetectable images, there is no specific identity that can be assigned to the character, and thus, they allow for the reader to easily identify with them and immerse himself in the story, giving him greater room for interpretation and perception.

According to McCloud [29], it is true that comics is a mono-sensory visual medium, but it tries to embrace the five senses as well. The same objective was sought after by Abstractionists, particularly, the Russian painter Wassily

Kandinsky who is generally regarded as the pioneer of abstract art. Kandinsky [30], through his abstract or non-figurative art, uses shapes, lines, colors, forms and gestural marks to achieve his goal in provoking a profound emotional response that utilizes the five human senses through one single artwork. Similarly, McCloud professes that comics can perfectly unite the five senses through abstract images. To him, an image can be abstracted in two directions; either directly from resemblance while retaining the meaning, or away from both resemblance and meaning towards the picture plane [29].

In summary, both comics and abstract art seek to embrace the five senses and evoke the emotions through abstract images that do not represent an accurate depiction of reality, but still retain the complete meaning. Comics use symbols and icons among other visual vocabulary elements, while abstract art uses colors and geometrical shapes to achieve its effects and convey its messages. Kandinsky for instance, relies on the nature and meanings of colors and shapes and how they can evoke distinct emotions and reflect diverse meanings [30].

Furthermore, in both art forms there is the aspect of openness, which dictates that the whole process of interpreting any abstract artwork depends on the viewer himself. It is his responsibility to put the lines together, decipher them, and disclose the sought meanings of that artwork. In comics, as in abstract art, the lack of clarity can be used as a useful tool to evoke greater participation and involvement from the viewer.

1.3.1.5 NONLINEARITY

In his “*Poetics*”, Aristotle [31] states that *drama* (story, novel, play, film...) should imitate a whole action, which means that the events follow each other in a direct causality pattern, and that the causal chain has a beginning, middle, and an end. In 1863 the German playwright and novelist Gustav Freytag wrote his book *Die Technik des Dramas* [32] in which he coined what has come to be known as *Freytag's Arc* or the *Narrative Arc* which consists of five parts: exposition, rising action, climax, falling action, and dénouement or resolution. This is the traditional linear pattern and order of the events presented in any dramatic work. Nevertheless, world literature has celebrated several distinctive dramatic works that abandoned the linear order of events starting from Homer's epic poem *Iliad* in the 8th century BC until the modern age with its HTML narratives, video games, digital stories, films, and novels such as *The Night Circus* [33], *Station Eleven* [34], *The Year of The Rat* [35], and others. The objective sought after by such nonlinear dramatic works is to mimic the structure and recall of human memory in its

intuitive understanding of the events that it encounters. Consequently, the reader/viewer will mentally sympathize and profoundly get involved within the story, trying to figure out what is going on as much as the main character does. Another goal is to catch the reader's/viewer's attention and induce him to keep reading/viewing, which is a literary technique that is called "*narrative hook*" [36].

Comics, as a narrative medium, is one of the dramatic structures that do not embrace the linear order of events, and thus, do not follow the rules of space and time. McCloud argues that comics employ nonlinear narratives because they rely on the reader's choices and interactions as a tool to engage him within the story. He also considers the gutters that separate framed panels from each other as primary tools to engage readers [18].

In fact, nonlinearity is one of the main features that distinguishes comics from other media of visual representation such as film and motion pictures. While the structure of comics consists of a series and juxtaposed panels that can be read in both nonlinear and sequential patterns, the structure of films and motion pictures narratives usually follows a linear and chronological order, where the exposition sets the tone and theme of the story, followed by the rising action, which leads to the story's climax, followed by the falling action and the dénouement, or the finale. The reader's eyes can scan the whole page in a comics story before starting to concentrate on a particular panel or event, while in linear films the viewer has to follow the events sequentially and chronologically so as to understand the story and its plot. Additionally, comics cannot be represented to readers as one panel at a time, because every panel is linked to the other in a network of relationships, and the gutters between panels are essential parts of the story, and not just dividing spaces, since they represent a transition from one moment or event to the next within a story.

Many comics scholars have discussed the relationships and transitions between panels, such as [18] [17] [28] [20]. Cohn states in [28] that the relationships between the panels in a comics story follow a cognitive system and schema; he identifies six types of panel categories that form the structure of comics narratives: orienteer which provides superordinate information such as settings, establisher which sets up the interaction, initial which initiates the tension of the narrative arc, prolongation which expands the state of time or extension, peak which represents the climax of narrative tension, and finally the release which releases the tension and brings the end. Cohn mentions that the peak is the most important category, followed by the initial as the second most important one; he also argues that the relationships

between panels form a hierarchical structure in which the panels are connected cognitively to each other.

Modern comics emphasize the concept of nonlinearity through adopting dynamic and non-traditional designs for page layouts in which panels can take different shapes and sizes. Such layouts are intended to affect the perception of time, and to highlight certain scenes over others based on their contents and importance to the plot, or to evoke emotional responses from readers to particular events in a much more dramatic way.

1.3.1.6 GUTTERS AND CLOSURES: INVISIBLE EVENTS

The gutter is another significant and distinguished feature of comics. It is the blank space that separates two panels within the story and creates a transition from one event to the next through evoking the reader's imagination to take two unconnected images and mentally construct them into a single idea, and turn them into a continuous event. According to McCloud [18] the gutter is used to *“take two separate images and transform them into a single idea”*. The gutter also allows for the concept of *“closure”* to take place within the story by challenging the reader to fill in the gaps between images with meaning that connects the panels and completes the narrative flow. This concept of *“closure”* is defined by McCloud as the *“phenomenon of observing the parts but perceiving the whole”*. He goes on to explain: *“Comics panels fracture both time and space, offering a jagged, staccato rhythm of unconnected moments. But closure allows us to connect these moments and mentally construct a continuous, unified reality”* [18].

Activating the concept of closure through the reader's formulation of a narrative chain to logically connect the panels differs from one reader to another, since different readers have different imaginations, thoughts, and expectations that will lead to different closures, and consequently different ends. Nevertheless, the author can greatly influence these conclusions through the use of different types of panel-to-panel transitions within the gutter. McCloud [37] [18] identifies the following types of transitions with each requiring a different degree of closure from the reader:

1. **Moment-to-Moment:** when something moves or changes slightly over a very small-time frame.
2. **Action-to-Action:** transitions show a single subject progressing through a specific movement.

3. **Subject-to-Subject:** transitions stay within a specific scene or idea and call for more reader involvement.
4. **Scene-to-Scene:** transitions take place across significant distances within time and space.
5. **Aspect-to-Aspect:** is unique in that it shows different aspects occurring simultaneously within the same scene.
6. **Non-Sequitur:** provides no logical relationship between panels.

In contrast, Duncan and Smith [17] argue that readers add nothing to fill in the gaps between the panels. Instead, they state that the “*reader performs closure within each panel, between panels and among panels*”. To them, the gutter’s job is only to arrange the panels and break up the sequence into “key moments”, and it is the panel that guides the readers to comprehend the whole storyline and activate temporal and narrative closure while reading. However, one cannot deny the significant function of the gutter within the comic pages and panels, if at least through its ability to foster the reader's engagement, evoke his/her cognitive abilities, and stimulate time and motion through the concept of closure.

While the different actions in other narrative media such as films are connected visually by the medium itself rather than mentally by the viewer, the comics' reader is triggered to mentally comprehend the invisible events that take place in between two seemingly unrelated panels, even though there is no panel containing what actually happened there.

1.3.1.7 ICONICITY AND SELF-REFLEXIVITY

Another distinctive characteristic of comics is the use of icons to represent general ideas, concepts, and meanings. In semiotics, iconicity is the natural resemblance between the form of a sign and its meaning or what it refers to in real world. In visual language, it refers to the ability of a visual representation to signify what it stands for. An icon can be an image such as a logo, or a person who represents an idea or style. In comics McCloud defines *icon* as “*any image used to represent a person, place, thing or idea.*” According to him, graphic icons universalize the narrative, allowing the reader to involve himself more directly in the events and, consequently, consider these events from his own point of view, rather than from that of the characters. Thus, the

cartoon character becomes “*just a little piece of you*”, permitting “*viewer identification*” [18].

To achieve iconic representation in comic narratives, McCloud depicts a progression scale with *received* information at the far left of the scale and *perceived* at the far right one. While received information can be easily understood because it tends to be naturalistic, accurate and detailed drawings, the perceived one requires specialized knowledge to decipher the abstract symbols and perceived icons since they are usually esoteric and elaborate language [18].

Simplification is the tool that McCloud recommends using so as to achieve iconic representation. He avers that the more simplistic or abstract an image is, the more easily we can identify with it; and the more realistic it becomes, the harder it will be for us to empathize with it. The point behind this is that a cartoon has the ability to concentrate and focus the reader’s attention on the idea; it provides a universal conception instead of limited and concise one. It, furthermore, enables the reader to escape from actuality and travel to other realms and fantasy worlds, as it allows him to map himself in the story world and become the character instead of watching him [18]. The successful utilization of all these potential abilities of comics is contingent on the artist's drawing style since it is the manner through which he portrays the subject matter and the creative tool through which he narrates the story and expresses his own vision of it. Besides, different styles provoke different emotional responses and visceral feelings among readers and viewers [17], as they dominate the reader's initial attention to the story as well as his consequent engagement within it [20]. Drawing styles need to accommodate the genre of the story being told so as to create harmony between the nature of the story and the style of its representation; for instance, crime stories are usually drawn in a dramatic noir style to reflect the melodrama and ambiguity of such stories [38].

Another feature of comics and cartoons is their self-reflexivity in terms of their ability to reflect on their own nature through the visual language and almost without words [25]. Comics narratives usually require less cognitive effort from the reader than word-based ones, as they are able to convey a wide variety of meanings, complex messages, and abstract concepts much faster and much more accurately than words. With reference to the English-idiom that says, “*a picture is worth a thousand words*”, one can easily write a one-thousand word essay about a single painting. Images and pictures by their intrinsic nature can convey a wide array of messages and meanings, and evoke diverse emotional responses and behavioral reactions. In visual

storytelling, they can exquisitely tell any kind of story without using a single word, and when placed sequentially, they have unparalleled power in capturing the reader's attention and engaging him within the storyline [20].

Comics scholar Neil Cohn [28] argues that comics is a medium written in visual language, and the drawing process is not originated from perception but rather from schemas that are stored in memory and combined through systematic rules, similar to that of any language. Hence, comics narratives emerge from the combination between verbal writing and visual writing, where the visual one is the drawings that consist of graphical lines, pictorial elements, iconic representations, and conceptual symbols represented in a personal artistic style.

1.3.2 SUITABILITY OF COMICS AS A REPRESENTATION MEDIUM FOR GENERATIVE APPROACHES IN STORYTELLING

The unique hybrid nature of comics which relies on just static images and text to convey ideas, implies that comics have the ability to convey events in much less given information than other hybrid medias such as motion pictures require; while comics can represent a particular event or action for instance in a few static images and sometimes only one, motion pictures require an extensive set of information to convey the same event. Such information can be either descriptive of the event itself or technical information required to simulate motion and sound effects. Thus, comics seem to be simpler and more suitable for representing the output of generative systems which tend to be concise and limited in nature, therefore eliminating the need for extra information or processing.

Openness on the other hand, is indeed suitable for generative applications in storytelling in general, and for this contribution in particular. One reason for this is that the emergent stories are generated from agents' behavior and their actions towards each other which do not provide enough information or details about stories' events; in such case a medium of representation that has the ability to fill in the gaps and provoke the reader for interpretations is believed to be more suitable than other media.

The nature of generative story characters is usually simple in structure, and characters' personalities are equipped with limited number of internal states and emotions. Nonetheless, each image in all of its simplicity represents something greater, something that is abstract and recognizable by all

audiences. This makes them fit well and accommodate with McCloud's model of "*amplification through simplification*". Thus, the simplification style of comics drawings is considered to be interesting and suitable for portraying generative stories' characters.

Additionally, the majority of comics are serialized with the events revolving around the main character and sometimes without climax or final problem to be resolved. This makes them closer to the character-based approach than the plot-based one, and perfectly relevant for the output of this project in particular and agent-based systems in general.

Furthermore, a framework that models characters in term of interacting agents whose internal states (emotions, feelings, and resources) are determined by an interactive process between those agents can be quite successful and suitable for creating comic characters to be used in generative storytelling compared to other forms of narratives. Characters in complex realistic narratives, robots, or interface agents that are designed to emulate a broad spectrum of human emotions, would require a large number of internal states and much higher dimension. This in turn, will make the evaluation process of the final result much more complicated and difficult.

Abstraction is a major theme in generative visual art. The employment of generative methods to create abstract paintings or images, is for instance believed to be much more efficient and easier than employing it to create realistic images; this is due to the complexity required to create realistic images by computational algorithms. Thus, the strong relationship between abstractionism and generative methods at one hand, and the similarities between comics and abstract art on the other hand, nominate comics to be the most suitable medium of representation for generative approaches, taking into consideration the added value of gutters in comics and its valuable contribution to the aspect of openness.

Moreover, a visual language such as comics can be much more suited to display generated narratives than written text. Transforming the stories that emerge from autonomous systems into interesting and rich text-based ones is a very complex process that requires employing methods from computational narratives, while transforming them through visual language that has its own vocabulary such as, line, space, shape, texture, and color, is easier to create, more interesting to be read, and more provoking to be engaged with.

1.4 RESEARCH CONTRIBUTION IN LIGHT OF THE RESEARCH QUESTIONS

Creativity is a crucial element in producing artistic works; it reveals itself not only through creative and outstanding ideas, but also through the materials and production media that artists choose to carry out their ideas. Consequently, the pursuit of new ideas, methods, materials, and tools for creating art works is a significant part of practicing art.

Creative pursuits such arts and storytelling have been deeply and intensely affected by digital technologies' implementation and the vast capabilities and possibilities they offer. In the past few decades, we have witnessed the invention of unprecedented tools, methods, and materials that has led to the rise of new forms and genres of art that were not experienced, known or practiced before. Yet, the utilization of digital technology and computation in creating and performing art is undoubtedly not limited to what we have already witnessed; as this technology is in continuous development and expansion, and it has the ability and potential to provide us with more tools and abilities to probe new horizons and accomplish new tasks and achievements.

The implementation of digital technology in storytelling has led to the rise of two main forms of narratives: generative narrative which is the result of exploring and employing computational methods for automating the creation of story plots either completely or partially, and interactive narrative which refers to works that are created or used through an interactive process with the creator/user.

These new forms of narrative have attracted the attention and interest of many scholars and researchers during the past few decades. A review of related literature of interactive drama is given by Arinbjarnar et al. [39]. Examples of research in generative storytelling include but are not limited to [40], [41], [42], and [43].

As a storytelling medium, generative comics has also been investigated by researchers but on a smaller scale, and the general contributions in this field of study are still modest. Part of these contributions focused on creating or placing specific comics elements such as speech balloons [44] or frame selection [45], other works employed comics as summarizing medium for videos [46], [47], [48] and games [49], [50], while others focused more on the technical perspective of generating comics than comics as a medium [51] and [52].

The research presented in this thesis deals with comics as a comprehensive storytelling medium that possesses unique features and qualities; it describes an approach for creating comics through employing generative methods and taking into consideration comics features and unique characteristics in the generating process. Thus, it relies on a profound understanding of the various fields of this cross-disciplinary research; comics, multi-agent systems, interactive evolution, and storytelling.

Henceforth, this work contributes to the previously discussed issues by investigating and exploring different methods of utilizing digital technology, particularly generative methods of computing to create new forms of storytelling/art through integrating some of the abilities of digital technology with human creativity. This is done by presenting and implementing an approach to generating comics through building and using a system that consists of three layers: a multi-agent system, interactive evolution, and a comics generating engine.

The system has shown high flexibility in how it can be used, and for what purposes. It can be used as a tool to help artists and writers in their process of creating characters and stories through presenting suggestions for story events and characters to choose from or develop for further iterations. Likewise, it can be used to design story characters and influence their personalities either directly through customization and modification, or indirectly through evolving new generations of characters. Hence, the system enhances and influences artists' inspiration through suggestiveness and producing unpredictable story events or characters' behaviors, as well as simplifying the process of storytelling and speeding its pace.

Furthermore, this thesis contributes to the art of comics creation by presenting an unconventional way that integrates human creativity and the machine's ability in the process of producing comics, where the machine becomes a co-artist and not just a standard tool for drawing, coloring or publishing.

In summary, the comics generative method and the system presented in this thesis contribute to the answers of the research questions by simplifying the story characterization process, where characters are suggested rather than designed from scratch as in the traditional style of characterization. It also integrates human creativity, imagination, and perception in the generating process making use of a human's superior abilities of observing, understanding, and evaluating aesthetics in comparison to machines.

Furthermore, the products that result from the implementation of this method can be seen as new forms of comics in which machines become co-storytellers and participate in generating art works. However, this form of comics is not claimed to be better than conventional comics by any means, but rather to introduce a new form of art that resulted from investigating and exploring the possibilities of employing digital technology in creating art works, and to show that generative methods are indeed worthy of being studied and explored by future researchers.

1.5 CHAPTER SUMMARY

Digital technology is one of the important achievements of mankind that has transformed almost every aspect of our life. However, digital technology is still far from entirely replacing human creativity, as creativity is the synthesis of human inspiration, imagination, and improvisation. Still, both digital technology and human creativity can be integrated to produce effective helping tools for artists in their creative process and quest for distinctive artworks. To this end, this research is conducted to present an approach that can be used as an assistant tool by artists in their process of creating fictional comics and characters as a new form of computational arts. The presented approach focuses on generating comics-based narratives through a system that integrates three main components in the creation process, which are: an agent-based system which is responsible for generating raw narrative material based on the behavior of the system's agents and the interactions between them, an interactive evolution process where the artist/author intervenes to participate in the generation process, and a comics generating engine that creates final and ready to read comic strips as outputs.

The research adopts comics as representation medium for the generated stories. As any other art form, storytelling has basic elements that constitute its form and structure; characterization is one of these elements that should be carefully handled by the artist since it is essential to the success of any story. The research focuses on characterization through using an interactive agent-based system to design characters, and generate comics strips from the interaction between these characters. The general scope of the research is narrative generative art coupled with the employment of comics as representation medium, and its main purpose is to construct a generative system that has the ability to create fictive characters for comics narratives.

The research utilizes a practice-led research method where the professional practice plays an instrumental part in the inquiry process. Relevant aspects of

computer science, visual arts, generative comics and interactive storytelling have been linked together to design and create a unified research project that can answer the research questions which are: how can digital technology be employed in generating comic stories; how can it contribute to the creation of new art forms; and how can it support artists in their creation of artworks?

The qualitative-based theoretical part of the research utilizes the method of Research through Design (RtD) which favors constant evolution and iteration of the construction of the artefact based on trial and error to better solve complex design problems.

The research presented in this thesis contributes to the answers of the research questions by presenting an approach to generating comics that consists of three components; a multi-agent system, interactive evolution, and a comics generating engine, and implementing this approach in a system, in which the machine becomes a co-artist. Another contribution is introducing a simplified method of creating story characters and events, which is capable of producing a different form of comics.

2 THEORETICAL FOUNDATIONS

This research integrates concepts from the disciplines of comics, narratology, fictional characterization, multi-agent systems, and evolutionary algorithms to present an approach that can be used to achieve the goals stated above and answer the research questions. This chapter provides an overview of the relevant topics of study that have been investigated during the conduct of this research.

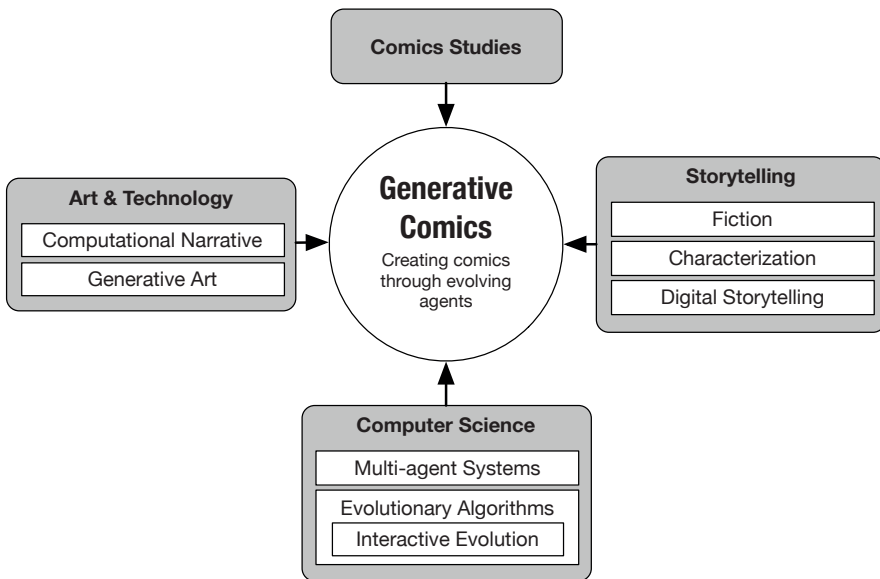


Figure 1. Overall illustration that represents the knowledge base of the presented approach.

2.1 TECHNOLOGY AND ART

Throughout history, inventions in different fields of human practices have provided means for artists to create and develop new tools and methods to help them in achieving their tasks. Musical instruments, painting pigments, and drawing materials are just a few examples in this regard. Currently, digital technology and computers have transformed the way through which artists perceive art and practice it, as they have offered new tools that can help the artists to transform traditional art forms, serve a variety of artistic

needs, and push the barriers of creativity and imagination towards innovative and untrodden paths.

Computers and digital technology provide the ability to create new art tools in the form of software programs and hardware devices, which can help artists in performing and creating their artworks. While such tools increase the artists' performance speed, and expand the scale of their work, they also provide the ability of creating detailed and realistic artworks that were impossible to realize before [53].

Since art is a creative practice that emerges from artists' imagination and inspiration, the employment of computer and digital technology based inventions has provided unimaginable means for creating art, expanded the frontier of the art world by offering new and unique forms of arts, and brought methods to support and enhance artists' imagination and inspiration by providing them with different options and alternatives to choose from as raw artistic material for further enhancement and development.

Computer programming allows the creation of infinite and versatile tools to support art practices; the developments in this field along with the advancements in intelligent algorithms have provided new techniques and capabilities that can be employed to create artworks. One of these capabilities is expanding the artist's vision and perception by offering new ideas or alternative solutions for the tasks in hand instead of following a step-by-step process which may restrain the artist's vision and limit the imagination. Offering alternative solutions can free the artist from a systematic order of thinking and provide an array of options that were previously inconceivable.

Evolutionary algorithms are sets of algorithms that have been used by researchers and practitioners for optimization purposes and to solve problems; they are based on the theory of evolution, and thus, on the concept of the survival of the fittest by which they perform optimization tasks with the ability to evolve. They rely on three components: a population of possible solutions, selection based on a fitness function, and mutation [54].

Interactive evolution is a method of evolutionary algorithms in which the reproduction of a given population of subjects, or the evolution process of that population, is performed through an interaction procedure with the artist/creator [55]. The employment of this technique allows the artist to participate in the process and become an active part in procreation rather than a passive one. The common way to implement this, is to let the artist

determine the fitness function by selecting the subjects that are allowed to survive to the next generation.

Since the introduction of interactive evolution by Richard Dawkins, who demonstrated its potential in graphics [56], several studies have been conducted on the topic and many generative artists have adopted it in different forms of creative works such as music [53], color art and image [57] [55], computer sculptures [58], and paintings [59].

Aesthetic evaluation is an elusive and subjective matter that depends on concepts that are very difficult and complex to represent in mathematical equations and algorithms, such as personal taste, and visual preferences, while humans are capable of performing such tasks much easier and faster than machines [53]. Consequently, assigning the ability of evaluation and judgment to artists by using interactive evolution methods does not only provide better and more efficient results, but integrates human creativity in the design process.

While interactive evolution is an interesting method to use for artistic purposes, it is worth mentioning that the past few years have witnessed huge progress and advancements in the fields of generative data such as deep learning networks² and GAN (Generative Adversarial Networks) which focus on generating data from scratch by combining two deep learning networks in the generating process which serve as generator and discriminator [60].

In most of the simulations of this research, an interactive evolution technique was applied in the process of reproducing new generations of characters based on the artist's observation and desire. The artist himself decides if a character is interesting enough for reproduction or not; if so, the character genome is saved in a population pool. The system allows the artist to select and save as many characters as he likes, then he can initiate the evolving process to create new generation out of the selected population. These simulations showed interesting results in characters' behavior and attitude; the newly generated characters appeared to be more social and dynamic in their behavior than their ancestors.

² For information about deep learning networks see [192].

2.2 STORYTELLING AND NARRATION

“All the world’s a stage, and all the men and women merely players;” [61], a Shakespearean poetic verse that states that life is an extensive interactive story in which men and women *“have their exits and their entrances,”* and are simultaneously the characters and the viewers. As characters, each has his own tailored role to play, *“and one man in his time plays many parts,”* and drives the storyline through his actions and reactions. As spectators, we are given the absolute freedom of choice, thus we affect and shape the end of the story through our interactions and choices. Hence, we do not overstate if we say that we, as humans, are story creators and consumers, and that storytelling is the oldest of all human endeavors to communicate, socialize, learn and educate. As far back as anyone can imagine, people told and listened to stories that shaped their existence and formed their culture.

Whether it be fiction, history, mythology, gossip, daydreams, news, or autobiography, stories are an intrinsic part of our societies and culture, and they permeate every aspect of our lives. They play a vital role in shaping our understanding of the world around us since they are the windows to the past, the snapshots of the present, and the glimpses into the future. Stories are everywhere, filling our cultural and social environments, and they were, and still are, used to define, preserve, and shape people's existence in relation to both their culture and their universe [62]. Through stories we define our values, desires, dreams, emotions and even prejudices and hatreds. The history of stories is quite ancient, lost in the mist of time; nobody knows when the first story was actually created and told, but before man learned to write, he had to rely on his memory in learning, teaching, and communicating. To transfer his history, culture, values and heroic deeds he relied on both the stories that passed orally from generation to generation, and the images that he drew on the walls of caves and residential places [63]. Thus, stories were coupled with images to form the first and foremost medium through which man was able to preserve his history and culture and transfer them to the coming generations.

The process of telling these stories is an ancient folk art that has emerged and evolved alongside with the development of the human race since its beginnings on Earth. Storytelling is traditionally associated with oral presentation; nevertheless, it has evolved in relation to the changing needs of society, from its origins in prehistoric times to the continuously changing digital age.

It is believed by most historians and psychologists that storytelling is one of the many things that define and bind humanity. It has always played a role in the evolution and survival of cultures. Humans are perhaps the only species that create and tell stories which blend fact and fiction through a broad range of imaginative and descriptive language that aims to entertain listeners, teach them and provoke their emotional responses and intellectual perceptions. The main goal of storytelling is to help us understand ourselves, the world we live in and our history. History itself is nothing but a series of stories that, when narrated attractively, can teach us lessons, give us insights into a variety of concepts, and entertain us. Thus, storytelling is not used for entertainment purposes only, but as a motivational and effective tool for educational needs, imagination enrichment, cultural preservation and emotional well-being [64], [65], [66], [62].

The history of creating and telling stories, though not easily traced, reveals that the narrated stories had come in all varieties such as myths, legends of all kinds, fairy tales, trickster stories, fables, ghost tales, hero stories and epic adventures. In short, all these varieties are meant to summarize human experience, which is a series of never-ending, overlapping stories bumping into one another in expected and unexpected ways [67]. But in general, there are two main categories separating these different genres of stories, which are fiction and nonfiction. Nonfiction sits in direct opposition to fiction and includes many genres such as essays, biography, autobiography, speech and narrative nonfiction. On the opposite side fiction covers other genres such as novels, novella, novelette, short story, drama, fables, fairy tales, science fiction, folklore, comic strips, graphic novels, legends, mysteries and mythology [36].

Like any other human behavior, storytelling has drastically developed throughout the ages; from cave paintings to oral narration and written texts, to visual and interactive representation where the events are conveyed in words, images, sounds, and performances. Recently, and at the pace it evolves, digital technology has reshaped how we interact with each other and how we convey our experiences and tell our stories. Visual media such as TV, films, digital cameras, and animations have provided storytellers with the ability to greatly expand the scope of their narratives, helping to create characters and scenarios that would be impossible to produce in a live setting. With the rise of computational narratives, generative storytelling, transmedia narratives, smart phones, digital tablets and streaming services, technology has made both factual and fictional storytelling more accessible than ever before [8].

2.2.1 FICTION

Fiction and visual arts are probably the most common genres of human creativity. Fiction is the universe of any generated narrative, and a quick review of the world's fictitious literature reveals that imagination and history are the two main fountainheads through which writers and artists have derived, and still derive, their masterpieces of art. The importance of fiction stems from the fact that it gives us the rare opportunity to look at the world from various perspectives; and thus, see all of it at once. It deals with the things and issues that we value and crave, and the concepts that make us fundamentally human such as justice, equity, equality, conflict, passion, love, fear, sorrow, hatred, jealousy, and exaltation.

Therefore, an overview of literary fiction in terms of its meaning, purposes, features, types and elements can help and provide insights of how stories are generated, which will be valuable information for understanding generative storytelling.

Encyclopedia Britannica [68] defines fiction as *“literature created from the imagination, not presented as fact, though it may be based on a true story or situation. Types of literature in the fiction genre include the novel, short story, and novella.”* Merriam Webster [69] defines it as *“literature in the form of prose, especially novels, that describes imaginary events and people.”* Fiction as opposed to reality can be briefly defined by the words of the French philosopher Albert Camus [70]: *“Fiction is the lie through which we tell the truth.”* and the words of the 19th century American philosopher Ralph Waldo Emerson [71]: *“Fiction reveals truth that reality obscures.”*

As mentioned above, the combination between history and imagination in creating fictional artworks is crucial because our understanding of such creative works depends on our grasping the way of how a particular artwork is related to real life. It, furthermore, allows us to step inside the minds of those who have shaped the world we live in, and to imagine the all too human side of history as it shapes our ability to empathize with cultures and people that are foreign to our own experiences. Any piece of art, in one way or another, is an imitation of life; and this is the secret behind the joy and serenity that we feel when we read a story, view a movie or contemplate a portrait. We feel pleased because they give us an escape from the actual chaos of life and a short relief from the confusions, controversies and pressures of our daily existence. These imitations are usually presented to us in various forms and perspectives so as to reflect the diversified states of life. This is so because life itself is not a constant state of being; it is neither tragic

nor comedic, neither romantic nor ironic. It is in fact a sequence of events and states, perceptions and sensations, actions and reactions that artists try to reshape with words and brushstrokes. This representation of existence and real life is a taming process through which artists try to acclimate us with its overlapped, interlaced, and controversial states and events. Thus, all types of arts are but a very highly developed method of life formation process.

Within this spectrum from history to fantasy, there are two principal tools that artists use to tame real life and embellish it, which are realism and romance. Realism is a matter of perception through which the artist presents his viewpoints and impressions of real life. Romance, on the other hand, is a matter of vision and imagination through which the artist reveals his ideas about real life and the artistic inspirations that might be gained out of it. Thus, realistic perception, romantic inspiration, affluence imagination and sharp vision are essential requirements and vital mechanisms for any artist who seeks to produce memorable artworks. Artists throughout history have strived to acquire these abilities so as to create artistic worlds that are remarkably close to our senses and to make us aware of the logical reason and profound meaning of our existence.

To sum up, fiction is a major branch of literature that focuses on the use of imagination to create narrative or informative literary works that are derived from both factual and nonfactual or imaginary events. It might sometimes rely on facts that come from history or the writer's experience, but still, they will be presented in writing as though they are part of the world represented in the story [72]. Because fiction is an art and not a science, there are a number of basic and essential elements that should exist in any literary work to be considered as an artistic piece of fiction. Without these elements, any written piece would cease to make sense or serve a purpose. These major elements are character, plot, setting, style, design, theme, point of view, and symbol [73], [74], [75]. Just as the painter uses brushes, paints, colors, perspective and other aspects of visual art to create an artistic painting, the literary writer combines and relies on the above-mentioned elements to create his own piece of art in the form of a story or novel. The relative importance of each element varies immensely from one work to another, depending on the author's style and purpose. Setting, for example, might be the most important element in a work and almost non-existent in another. Character development is the key element in a story's creation; and in most pieces of fiction, a close identification with the character is crucial to understanding the whole story and its main theme.

2.2.2 CHARACTER & CHARACTERIZATION

In storytelling, characters are the heart of any literary work since they are the momentum that moves the story ahead, and the ones who create the conflict and resolve it [76] [73]. Thus, the success of any narrative work depends to a great deal on the writer's ability to spellbind his readers through creating unforgettable characters, as well as his ability to develop unique and life-like ones.

Characterization is the process of creating a believable character in a story or novel through informing the reader about the personality traits, thoughts, actions and reactions of that character. Thus, it is a literary device that is used step-by-step to explain the details about a character in a story [75] [77].

An important part of characterization is dialogue (both inward and outward), because it affords us the opportunity to see into the characters' hearts and examine their motivations. In the best stories, it is actually characterization that moves the story along from the beginning to the end [78]. Good writers have always seemed to understand that what people say and do reveals more about them than how they look. Thus, they have tended to rely more on description so as to establish memorable characters in the mind of the reader. For example, Shakespeare's works have superb characterization in comparison to *Pilgrim's Progress* [79], written in 1678 by John Bunyan. Thus, the author who wants to create great stories must characterize well [80] [74]. To this end, literary writers employ what is known as the "*methods of characterization*" to develop their characters into memorable and captivating ones. Roughly speaking, there are two different methods to characterization which are the *direct* and *indirect* approaches. With the direct approach, the author *tells* us explicitly what he wants us to know about the character; and the character's personality is revealed by the use of descriptive adjectives, phrases, or epithets. With the indirect characterization, the author *shows* us things about the character to help us have an understanding of its personality and effect on others. Thus, the character's personality is revealed by showing rather than telling. This is achieved through illustrative dialogue, actions, interactions, deeds and appearance (i.e., dress, posture, or expressions) [77] [81].

In storytelling, as in real life, we can evaluate a character in three ways: through what he says, what he does, and what others say about him [82]. Collins [78] considers that character is everything in literary fiction, as it is crucial to any successful narrative work. This, of course, does not mean that it replaces plot, theme, setting, style, language, meaning or point of view, but

it intimately relates to them all. Characters such as *Hamlet*, *Othello*, *King Lear*, *Sherlock Holmes*, *James Bond* - to name a few - are engraved within our minds, though many of us do not know their creators/authors. The same can be said about many comics characters such as *Batman* and *Superman* (DC Comics), *Hellboy* (Dark Horse Comics), *Wolverine*, *Magneto*, and *Ironman* (Marvel Comics), *Kermit the Frog* (The Muppet Show), *Donald Duck* (Disney), and many others. The reason behind this attachment and memorization of such characters lies in the rational and convenient development of these characters, deep understanding of their personalities, reasonable underlying motivations, believable dialogue, authenticity, vulnerability, and the power to inspire and spellbind the audience.

2.3 STORYTELLING IN THE DIGITAL AGE

Technology has changed and affected everything we do and use in life, as it has revolutionized our perspective of the world around us. In such a world of accelerating change and rapid digitization, it is fairly normal for art and artists to be affected by the innovated and latest trends in technology; simply because they are prone to innovation, adept at seeking the unattainable, and infatuated with treading the untrodden. For them, every new technology is a new opportunity and tool that can be employed to create unique and spellbinding artworks. Furthermore, artists' styles and identities have always been influenced by the eras they live in; consequently, modern artworks are entwined with the present era of digital technology.

The synthesis nowadays between art and technology is stronger than it has ever been. Technology has not just provided new and unprecedented tools of production and distribution, but it has also created new art forms that has never been known before and redefined many others. Among those which were redefined is storytelling, which is an important part of how we, as humans, communicate, entertain, and teach each other.

The rise of digital technology has revolutionized the forms and applications of storytelling by creating new engaging experiences that attract the audience and provide thrilling and more effective ways of using stories to define, preserve and shape society. Digital storytelling, the product of this revolution, incorporates the power of the human creativity with the pervasive and powerful nature of digital media. It synthesizes multimedia based-elements such as animated and still images, video, audio recordings of voice and music, and text to create engaging stories and compelling accounts of experience. Carolyn Miller [83] defines digital storytelling as “*the use of*

interactive digital technology to tell immersive and participatory stories.... digital storytelling always have elements of narrative and always offer some degree of entertainment". Bernard Robin articulately defines it as "the art of telling stories with a variety of digital multimedia, such as images, audio, and video. Just about all digital stories bring together some mixture of digital graphics, text, recorded audio narration, video and music to present information on a specific topic." [84].

Digital storytelling is a vast discipline that contains many different media with different specifications and characteristics. The simplest form of digital storytelling can be represented by what is known as *digital publishing* which uses digital technology to rewrite printed material in various digital formats so that it can be accessed through computerized electronic devices. PDF, EPUB, AZW, LIT, ODF, CBR and MOBI are the most popular formats of the digital versions of books, stories, documents, magazines, and comics. The users' interactivity in such publications is usually absent or very limited and restricted to the use of internal or external links, and sometimes the permission to change font size and type or annotate pages, as it is the case of the industry standards for electronic/digital books, the EPUB and AZW3 file formats. These publications are designed and created to be accessed through computerized electronic devices such as desktop computers, laptops, touch tablets, smartphones, or e-book readers which are electronic devices specifically designed for reading e-books. *Amazon Kindle* [85], *Kobo Aura* [86], and *Barnes & Noble Nook* [87] are the most common e-book readers.

Digital publishing does not represent the full intrinsic capabilities of digital technology; it forms just a small portion of the large existent array of applications and mediums of digital storytelling. The most common and popular media of digital and interactive storytelling are video games. Carolyn Miller [83] though, states that there is a debate among scholars about the nature of games, and whether or not games can be regarded as a form of storytelling; on one hand narratologists like Janet Murray [88] agree that games are a form of storytelling, on the other hand ludologists (researchers of game studies) like Espen J. Aarseth [89], a professor at the University of Bergen assert that games should be studied as unique constructs.

Video games have become an enormous knowledge domain that offers diversity in genres, themes, and types that follow similar conventions to film or fiction genres. Miller [83] identified ten genres of video games: action games, sports and driving games, role-playing games, strategy games, adventure games, first shooter games, puzzles, fighting games, simulations, and platform games.

Video games are used for several purposes other than entertainment such as education, cultural dissemination, learners' stimulation, information sharing, advertising and promotion, as they have become widely accessible through the diversity and availability of many platforms that can be used for playing games. A decade ago, playing games was restricted to specific platforms such as personal computers, video game consoles, and arcade machines; but nowadays, most digital devices can be used as game platforms such as smart-phones, touch tablets, smart TV's, digital TV boxes, and even wearable devices such as smart watches and glasses.

Besides video games and the internet, digital technology has caused the rise of several media types such as multiplayer online games (MOGs), smart toys and robots, smartphones, immersive and virtual environments, and augmented reality applications. However, the impact of digital technology on storytelling is not only restricted to human-computer interaction and its applications as in most of the above mentioned media; many researchers have investigated and studied methods and approaches of using computers to generate stories and narratives, giving birth to new fields of study such as *computational narrative* and *generative storytelling* [90], [91], [92]. Evolutionary algorithms and agent-based systems are two common techniques that emphasize the role of characters in generating stories; these methods have been employed for generating stories by many researchers and contributions. A more detailed discussion of this topic will be presented in section 2.4.

Moreover, the developments and innovations in both digital technology and computer graphics have generated new tools and applications that have empowered storytelling with new and unprecedented tools for creativity, and a vast array of choices and capabilities. Three-dimensional modeling and rendering, motion graphics and special effects, and photo-realistic rendering, for instance, have deep impact on narrative media, particularly, animation and film production. Nowadays, many of the produced theatre movies rely intensely and massively on the use of these applications to create exceptional scenes that are impossible to make by traditional methods. Besides, 3D modeling and rendering based applications have influenced and provoked the rise of a new style of animation that has not only generated more attractive and appealing animated works than traditional cell animations or stop-motion animation, but also transformed the production process into a much easier, cheaper and faster one.

2.3.1 FEATURES OF DIGITAL STORYTELLING

Digital storytelling contains a broad range of powerful digital tools that vary significantly in their structure, purpose, presentation process, characteristics and features. While any digital storytelling medium has its own features that depend on its nature, one can observe common features that distinguish digital from traditional storytelling.

The important feature of digital storytelling is interactivity, which assimilates and conjoins the reader in the medium, equipping the reader with both choice and control abilities during his reading experience, and therefore transforming the reader status from passive observer to active practitioner. Interactivity allows the reader to control what to read and how to communicate with the material contents based on various rules that are determined by the material creator; therefore, the level and extent is not always the same. While a high level of interactivity gives users great control abilities, a lower level provides experiences closer and similar to those of traditional media.

Interactivity adds nonlinearity to digital narrative media in contrast to traditional media. Traditional storytelling media such as novels, animation, and film enforce users to follow a linear mode of reading or watching; the only thing they can do is to skip some parts and jump to others, which of course affects narrative comprehension and impairs their engagement experiences. Interactive storytelling, in contrast, does not restrict users' choices and decisions, e.g., it uses hierarchical networks to construct nonlinear stories and narrative structures in which the story events are dependent on users' actions and behaviors, which in turn affects the story plot resulting in different storylines and ends. A simple example can be observed in hypertext which allows readers to jump to the content they need without going through all the content linearly.

Portability and capacity are other important features of many digital storytelling media, especially digital publications. Beside the new tools and techniques for creating story contents, digital technology provides users with portable and convenient devices through which they can easily access digital contents in any setting. Laptops, touch tablets, smartphones, cloud storage, and e-book readers provide effortless means to access unlimited amount of digital data. One can for instance carry thousands of e-books in a device that weighs less than a half kilogram; a capability that is impossible to reproduce in traditional media.

Low costs of production and distribution is another feature that distinguishes digital storytelling; in the case of digital publications for instance, printing processes and traditional channels of distribution are not required, as digital materials can be accessed or downloaded instantly which saves considerable amounts of money and time for both the publisher and the reader. Additionally, the low cost and easy distribution make it easy and affordable for anyone to create, publish, and share his works.

Emergence is another important feature that attracts researchers in computational narratives and generative storytelling. The significance of this feature lies in the ability of narrative generating systems to generate and produce a wide variety of non-predefined stories that emerge from the interactions between the user and the system. The results of these emergent stories are usually unexpected even by the designers of the systems themselves. This property is very interesting as it implies that the final result is more than the sum of its parts [93]. In other forms of digital stories, especially in education-based context, emergence can be identified through the conjunctive use of multiple media to express a message or explain a topic; this combination of media can provide better understanding than relying on only one medium. Every medium has its own strengths and weaknesses; nevertheless, a proper and well-designed employment of different media together in one digital story has the ability to overcome the weaknesses and convey the intended messages clearly, effectively, and quickly.

Another important aspect of interactive digital storytelling is immersion, which can be described as the degree of involvement that the viewers have with the various aspects of the story leading to a redirection of their attention, awareness, and thoughts from the real world around them to the actions happening within the story; and thus, becoming deeply involved in it. This is achieved through integrated multimedia-based elements that provide the viewers/users with freedom of choice and control abilities by which they exert an influence on the story, as well as feedback devices that enhance and emphasize users' feelings and reactions to story events; and thus, the end/result of the story will vary from one user to another [94]. This can make the experience of reading/viewing an interactive narrative much more enjoyable and interesting than reading it through a traditional medium.

2.3.2 THE IMPACT OF DIGITAL TECHNOLOGY ON COMICS

Research and studies that explore the integration of digital technology and computer science in comics were conducted in different fields of research such as document image analysis, artificial intelligence, human-computer interaction and others [95]. Generally speaking, there are two main domains that arise from this integration: digital comics and computational comics. Digital comics explore the creation or releasing of digital versions of comics, and how they can be accessed and read through digital devices [96].

In his analysis of the nature and definition of digital comics, Côme Martin [97] asserts that many digital comics are digital reproductions of printed comics, and “...*some scholars see in digital comics only a technological variation of pre-existent means of distribution.*” He concludes that there is no real answer yet to the question of what digital comics are because the media they refer to is in constant mutation. However, there are several types of comics that became to be described as digital comics; the most common ones are: digital versions of comics (or digitized books in PDF, EPUP, CBR, etc. formats), web comics, motion comics, interactive comics, hypercomics, turbo media, and game comics. The fourth paper in this dissertation discusses this topic in depth.

The field of computational comics on the other hand, focuses on the methods that are used to analyze and generate comics, as well as the interaction between comics and readers. Augereau et al. [95] identify three main categories of researches in computational comics: content analysis which focuses on analyzing the contents of comics to extract useful information out of them; content generation which explores methods of generating comics contents or converting and adapting them; and finally user interaction research which deals with studying the relationships between the readers and the medium of comics, such as the readers' internal states and emotions and how they are affected by comics. Additionally, the authors identify five ways of generating comics: vectorization in which scanned pages of comics or raster-based comics are converted to vector graphics; colorization by adding colors to black and white comics; character generation which focuses on methods to generate visual designs for characters and related elements; animation by enhancing the presentation of comics through integrating animations such as animating camera angles of panels, faces, effects, and so on; and media conversion which focuses on converting other media such as text, video, or images into comics.

Based on the authors' analysis of the studies of generated comics, it appears that the focus is mostly on the conversion and adaptation side of creating comics, as they neglect the researches and applications that focus on generating the narrative structure of comics, or the comics creation approaches.

The concept of implementing technological features in creating and/or reading comics has been explored by many practitioners since the development of World Wide Web and reading devices. Some works such as hypercomics [98] which are web-based comics, consist of narrative structures that allow readers to influence story events through their choices. The term *Hypercomics* was first coined by Ted Nilson [99] to describe comic strips connected together through hyperlinks [100]. Hypercomics have been studied by many researchers and scholars, among them [101], [102], and [103]. However, the term is sometimes used by some creators as another synonym for web comics such as in [104] and [105].

Motion comics is another emerged form of technology inspired comics; the term refers to the amalgamation between comics and multimedia-based contents such as animation and motion graphics. Craig Smith [106] [107] defines motion comics as “...an emerging form of digital animation that typically appropriates and remediates an existing comic book narrative and artwork into a screen-based animated narrative”.

Comics have been the subject of experimental works in which practitioners have developed different methods for creating comics, as well as different forms of comics; for instance Philipp Meyer [108], an interaction design student at Potsdam's University of Applied Sciences developed a tactile comic book for the blind, Warren Ellis and Matt Brooker [109] included hidden dialogues in their comic “*SVK*” that can be seen by using UV light, and Chris Ware [110] created “*Building Story*”, a multi-perspective story with no beginning or end. Several other writers, authors and artists created comics in unusual and untraditional ways, experimenting with different methods and tools in their projects, for more examples see [111] and [112].

Some experimental methods have involved computational processes to generate comics. Randomness is one of the simplest methods in this regard, for example, *Random Comic Generator* [113] is an online application that is used by users to generate random comics. Further discussion about computational comics is presented in the next section.

2.4 COMPUTATIONAL NARRATIVE AND GENERATIVE ART

The increasing prevalence of digital technology and artificial intelligence is proceeding and bringing new discoveries and technologies to every facet of life at an unparalleled and breakneck pace. Therefore, scholars from various knowledge domains have become keenly interested in employing these new technologies in their fields of study or work, starting from social life, politics, economy and industry, to education, entertainment, health care, fine arts and creative writing.

The past few decades have witnessed a growing degree of interaction between art and technology, whether it is through equipping artists with new tools and materials, allowing more interaction between the artist and technological media, or simply making the creation and design processes much faster and easier. Hence, employing digital technology in art practices has helped artists to create new forms of art, and develop new and different methods of creating artworks than traditional ones.

Thus, an escalating interest in the implementation of digital technology and computer science in art practices is noticed among artists and scholars alike; many professionals in the academic and artistic fields became fascinated by the possible enrichment of such interaction. This widespread interest led to the rise of a form of art which became to be known as *generative art*.

Generative art was triggered by the developments in computer science and digital technology in the 1960's. It was deeply affected by both the rapid developments in this technology, and the ambition of artists and scholars who are attached to the idea of investigating and developing new methods and tools for art practice and creation. In short, generative art is the natural result of the technological advancements that have expanded the boundaries of art practices and provided artists with new tools of expression and creativity.

The term *generative art* is one of several titles such as *computer art* and *electronic art* that have been assigned to artworks created by employing a computer system, automated technology or algorithmic method [114]; later on, scholars started to differentiate between these titles as they appear to refer to different forms of art in some cases. This ambiguity of the nature of this art form motivated many scholars and researchers to find out and identify a clear criterion for what could be called "*generative art*", and to provide frameworks that can be used to categorize generative art works.

According to Philip Galanter [115], “*Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art.*”

Galanter provides a framework for defining generative art based on complexity theory where the systems used for making generative art can exist on a continuum from the highly ordered to the highly disordered systems [115]. Margaret Boden and Ernest Edmonds [114] consider an artwork to be generative if at least part of that work is generated by a process that is beyond the artist's direct control. They distinguish eleven types of art to form a taxonomy of generative art, which are: electronic art, computer art, computer-aided art, digital art, generative art, computer-generated art, evolutionary art, robotic art, interactive art, computer based interactive art, and virtual reality art. Another framework is proposed by [116] in which Alan Dorin and coworkers identify four main components that constitute a generative art system, which are: entities, processes, environmental interactions, and sensory outcomes.

It is a fact that computers have become an essential part of our daily life, and a common tool in creating generative art; yet, they are not the sole method or an indispensable necessity for this process [116] [115] [114]. What is required is the incorporation of an autonomous system or set of rules that define the basis of generating the artwork such as natural language rules, algorithms, genetic sequences, machines, or procedural interventions. Thus, we can say that generative art has actually existed before the age of computers. In fact, some scholars argue that generative art might be as old as art itself [115]. This claim is supported by the existence of what is considered to be an old era of generative art, such as Paleolithic ornamental art, hydraulically activated automata of ancient Alexandria, and the structured geometric patterns in Islamic Art from the 7th century onwards [114].

The reason why some artists are interested in generative art is completely subjective and personal; some artists are looking for more efficient ways to manage an extensive space of decision making [114], while others are looking for its ability to generate surprising and unpredictable outcomes, which is known as emergence.

As mentioned before, emergence is one of the most important features of generative systems because it has the ability to produce a wide variety of unexpected outputs that are more than the sum of the inputs. Gordon Monro

[93] describes emergence in generative art as “*the observed behavior or output of the artwork is unobvious or difficult to predict and evokes feelings of surprise, wonder, mystery and autonomy, even when we have complete knowledge of the construction system.*” While non-obviousness and unpredictability are interesting enough by themselves as results of making art, emergence has much to offer in terms of expanding artists’ conceptualization and extending the boundaries of their idea exploration.

The process of creating art is an iterative one [114]; a process that has always relied on the human factor as the source and tool of creativity. It normally follows a traditional and linear manner that consists of gradual development, refinement, and enhancement towards achieving the goals, which in turn, tends to limit the ability of exploring new ideas by restraining the artist to a linear and narrow way of thinking. Generative methods provide a plausible solution for this problem as they can provide a wide variety of options and solutions to choose from, or at least to provoke and expand artists’ inspiration and creativity. One of common methods used in this regard is the employment of nature inspired algorithms such as genetic algorithms and agent systems. Such methods have been applied to the creation process of many and various forms of art ranging from music composition to visual arts and architecture [53] [117] [118] [119] [57].

Many studies have been conducted in the field of generative storytelling, and various approaches have been explored and implemented in this regard. In general, these approaches belong to one of three types: a plot-based or scripted approach, a character/agent-based approach, and an intermediate/hybrid approach [120].

2.4.1 PLOT-BASED APPROACH

The basis of the plot-based approach goes back to Aristotle (b. 384 BC) and his book *Poetics* [31], which for millennia served as the main guide that writers had to plot and story structure. This approach focuses on achieving a pre-defined, well-structured plot of a story by characters who have no autonomy at all, and whose actions are determined by an agent that acts as a drama manager. Since this approach is based on a pre-defined structure and directed by one agent, it may limit genuine innovation and artistic creativity. To overcome this drawback an open-ended structure might be a good choice since the conclusions in this technique are not clearly stated, and the viewer/reader is left to resolve the situation with his/her imagination. In this context, the use of story beats is fairly common among authors to link the

events and generate the story. The beat is the smallest unit below the scene in the story structure (the moment when an action leads to a reaction). Together, beats constitute the scenes, and the scenes in turn constitute the sequences that create the acts which move the story ahead to its denouement. Mateas and Stern's *Façade* interactive story [43] is a good example of this technique. Story Generator Algorithms (SGAs) are another technique that uses computational procedures to generate a story [121]. A thorough review of plan-based approaches to generating narratives was given by Young in 2013 [122].

2.4.2 AGENT-BASED APPROACH

The agent-based approach focuses on creating the story plot content by using characters who are fully autonomous and free in their choices and actions. Their choices and interactions with each other create or affect the dramatic storyline without advance notice of plot or theme. One of the techniques in this context is the computational improvisational storytelling in open-worlds, where an intelligent agent can co-create a story with one or more humans through natural language [123]. Another technique relies on multi-agent systems that generate the story through the network of relationships that connect between the agents themselves and their virtual world. The physical actions and verbal interactions of the agents as well as their perceptions of the world are efficiently employed to achieve the plot coherence and character believability of the story [124]. Similar approaches provide more openness, surprise and unpredictability as stories emerge from the agents' interactions only without the need for a drama manager.

Agents and agent-based systems have been employed in many applications during the past decades such as video games which rely heavily on artificial agent systems and the use of intelligent virtual agents (IVAs), which are embodied digital characters situated in a virtual, augmented, or mixed reality environment [125]. A fundamental behavioral requirement of these agents is that they should exhibit some aspects of human intelligence, such as autonomy, communication, coordination, and learning capabilities. Thus, they are maybe based on computational emotion models which are intended to simulate human emotions and therefore add credibility and believability to the characters. Many studies were conducted in this field with different goals and themes in mind, for instance, [126] used finite state machines to control the characters' behavior and personality, [127] used a script-based system to add personality parameters to the characters, [128] used an emotion model

from psychology, and [129] proposed a Bayesian network-based model of personality.

2.4.2.1 EMOTIONS IN VIRTUAL CHARACTERS

Virtual agents are embodied characters that look, think, and act like humans [130]; modeling them can for example be based on cognitive appraisal theories of emotion and models derived from cognitive sciences and psychology [131], such as the Ortony, Clore and Collins (OCC) theory which assumes that emotions develop as a consequence of certain cognitions and interpretations.

Affective computing is another expanding field of research that emerged from the integration between computer science, psychology, and cognitive sciences. The term originates from Rosalind Picard's 1995 paper on how computers could express and recognize emotions [132], and her book published in 1997 [133]. It has become the common term used for that field of computing, and is now accepted to cover a wide range of topics relating to emotions, including emotional expression in robots and interface agents, simulated emotions in autonomous agents, and mechanisms for recognizing human emotional expression. According to Picard, *"if we want computers to be genuinely intelligent and to interact naturally with us, we must give computers the ability to recognize, understand, even to have and express emotions"*. A more recent overview can be found in [134]. Thus, affective computing is the study and development of systems and devices that have the ability to detect, recognize, interpret and process human affects or emotions (via sensors, microphones, cameras and/or software logic) and appropriately simulate them and respond to the user's mood or emotional state. Such systems and devices provide great values for many applications, human-computer interaction systems, control systems, indexing digital materials, and surveillance [135].

While the research presented here employs an agent-based approach as the core engine for creating and generating both the characters and the narrative structure, it is less concerned with affective computing or humanoid virtual agents; that is because these methods are concerned with simulating real human emotions and modeling human-like characters (e.g., [133], [136]). This goal differs from the scope of this research which aims to generate comic stories with simple, stylized and cartoony characters who possess much simpler and more limited emotions and personality traits, and do not need to emulate realistic human behavior. The characters of a comic strip created for artistic or entertainment purposes often engage in behaviors that

seem weird, bizarre or highly exaggerated when compared to human behavior. They may also have internal state dynamics that does not resemble typical human emotional behavior. However, it is still meaningful to compare this research with other approaches that describe the dynamics of internal emotional states of agents, in particular to learn about different representations and implementations of agent emotions.

The agents in this system are characterized by time-varying internal states that affect their choice of actions in different situations. The change in time of the internal state depends both on the environment and on the current internal state. These internal states can be seen as analogous to human emotions (or moods and affects, depending on terminology). Furthermore, the functions that map a combination of environment and actions of other agents together with the internal agent state to the agent's actions and change of internal state can be viewed as defining the agent personality.

Several early researchers argued for the necessity of including emotions in the cognitive structure of autonomous agents. In the 1960's and 1970's, the Japanese psychologist Masanao Toda developed a model of autonomous agents called Fungus Eater [137], which were simulated agents in a simple artificial life environment, and could be viewed as robots searching for food (fungi) and resources (uranium) while exploring the surface of the imaginary planet Taros in the α -Sapporo star system in 2061. In some versions of the model [138], Toda included agent emotions in the cognitive model. Herbert Simon also argued for the inclusion of emotions in cognitive agent structures in 1967 [139]. In Simon's approach, emotions were used as an interrupt mechanism for agents following a pre-determined plan but encountering new unexpected conditions.

An early implementation of simple emotional dynamics was in the paranoid chatbot PARRY [140] created by psychiatrist Kenneth Colby in the early 1970s. In a Turing test setting, PARRY convinced a number of human interviewers that it was an actual human with paranoid schizophrenia. These ideas were further developed in the 1980s by several researchers, among them Aaron Sloman [141], Rolf Pfeifer [142] and Michael Dyer [143]. Other researchers who have argued for the necessity of including emotions in cognitive agent structures are for example the psychologist Dietrich Dörner [144], Marvin Minsky in *Society of Mind* and *The Emotion Machine* [145] [146], and neuroscientist Michael Arbib [147].

Overviews of different approaches to the computational modeling of emotions in agents can be found in review articles by Hudlicka [148] and

Rodríguez and Ramos [149]. Some of these approaches view emotions as discrete basic entities based on the classification of basic emotions by researchers such as Paul Ekman [150]. Joy, sadness, anger, fear, disgust, and sometimes surprise are often considered basic emotions.

Some models place considerable emphasis on appraisal mechanisms (i.e., mechanisms that evaluate the current environment of the agent to determine the emotional state). For computational modeling, the most popular of these is that of Ortony, Clore and Collins [151] (the OCC model), but related mechanisms by Frijda [152] and Scherer [153] have also been used. Other models place more emphasis on the continuous dynamics of real-valued emotions in time. These models often involve dynamics in a space of lower dimension than the number of basic emotions. For example, in the circumplex model of affect [154], a two-dimensional state space of valence and arousal or a three-dimensional space (pleasure-arousal-dominance) is used.

The models that structurally have some resemblance to the work of this thesis are primarily those that describe the dynamics of emotions in time in terms of difference or differential equations in a finite number of dimensions. These in particular include the work of Egges, Kshirsagar, and Magnenat-Thalmann on emotions and personality for conversational agents [155] and the work by Bryson and Tanguy on dynamic emotion representation [156], as well as that of Velásquez and Maes [157].

However, there is still a fundamental difference in that the internal states considered in this research are fundamentally arbitrary internal states that are not required to have an interpretation in terms of human emotions but could be given arbitrary labels. In the interactive evolutionary algorithm, the focus of the selection is on observing the behavior of the agents in an external environment, not on their internal states. Another major difference is the model of personality, which in this work is not constrained by being parameterized by a limited number of parameters motivated by models in psychology. This is discussed further in the following section.

2.4.2.2 PERSONALITY OF VIRTUAL CHARACTERS

Personality is also a field of considerable interest among computer scientists. The topics studied include personality perception, personality recognition and simulated personality in agents. An overview of personality computing is for example given by Vinciarelli and Mohammadi in [158].

In psychology, human personality is often described in terms of a finite number of descriptive traits, i.e., independent personality dimensions. The notion of stable personality traits goes back at least to the work of Gordon Allport [159]. Since then, different sets of personality traits have been suggested, such as Eysenck's three dimensions of introversion/extroversion, neuroticism/stability, and psychoticism/normality [160]. The model which is now gaining the widest acceptance is probably the five-factor personality traits model (FFM), also known as the OCEAN model, where personality is parameterized in terms of the traits of Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. For a history and more details of the five-factor model see, e.g., [161] and [162].

Computer modeling of human behavior and personality traits was a topic of research in the early days of computers and artificial intelligence [163]. For example, Loehlin carried out interesting studies of highly simplified models of behavior and personality, where he also studied interactions between pairs of agents [164] [165]. Loehlin's simulations were written in assembly code for a Burroughs 205 computer beginning at the end of the 1950s. The work of Colby on simulation of neurotic and paranoid agents [140] also belongs to this era.

Later works on personality of virtual agents has to a large extent viewed personality in agents as defined by a finite number of traits. The work on virtual theatre by Rousseau and Hayes-Roth in the 1990s [166] is an early example where trait-based models were used. In another early work by Rizzo et al [167], personality appeared indirectly through the choice of goals for the system. Recent contributions to computational models of agent personality have often made use of the five-factor model in combination with emotion models such as the OCC model. Some examples of such contributions are [168], [169], [170], [171] and [172].

Since there is no ambition of modelling human cognition in this work on comics creation, a more general and flexible concept of personality is used. From an implementation standpoint, personality is viewed as a function that provides a tendency to act in a certain way given current or past actions of the environment and other agents, as well as the internal state of the agent, together with a function that describes how the internal state of the agent changes. These functions can be represented and parameterized in different more general ways suitable to the interactive evolution process, including neural network models. Trait models of human personality such as the five-factor model can be viewed as particular finite dimensional parameterizations of these functions.

Another important point in connection with the present work is that the personalities of characters in a comic strip or movie are to a large extent inferred and constructed by the viewer from a small sample of their actions. As pointed out in section 1.3 in this thesis, this has also been stressed by various authors discussing the creation of comics such as [18], [20], [28] and also in the discussions of agent emotions such as that of [173]. The strong tendency of humans to interpret even abstract images in terms of human emotions and personality was shown in the classical work of Heider and Simmel [174], where viewers provided interpretations of an animated movie of moving geometric figures. Similar work was also done in the 1940s by Michotte [175]. The work by Braitenberg on designs for very simple robotic agents [176], now commonly known as Braitenberg vehicles, also illustrates these ideas.

In this work, the emphasis is on the behavior of virtual characters, which is the basis for the selection in the interactive evolutionary algorithm. Given the ability of viewers to infer the intentions and personality of agents, it is not unlikely that the complex machinery needed to try to emulate human personality and cognitive structure in more detail might be unnecessary.

2.4.3 HYBRID APPROACH

While a plot-based approach to interactive storytelling lacks the refinement of character behaviors, a character-based approach might distort the theme of the story since it does not follow a well-structured plot. Therefore, an integrated approach is a rational choice since it achieves the balance between the two approaches; it combines between scripted plots and semi-autonomous characters; and thus, conveys the story moral and enhances the modelling of character behaviors. While some of the works created through this approach provided more interactivity, others emphasized plot structure and therefore, less interactivity.

Some well-known works that tried to balance character-based and plot-based approaches and emphasize the role of human creativity is Crawford's *Erasmatron* [177], which uses a verb-based engine to generate the dramatic storyline. Another similar hybrid approach was proposed in [178].

2.5 CHAPTER SUMMARY

Computers and digital technology provide the ability to create new art tools in the form of software programs and hardware devices, which can help

artists in performing and creating their artworks. Interactive evolution systems have provided means for creating art and offered methods to support and enhance artists' imagination and inspiration by providing them with different options and alternatives to choose from as raw artistic material for further enhancement and development. On the other hand, computer programming has allowed the creation of infinite and versatile tools to support art practices.

In this research, an interactive evolution technique was applied in the process of reproducing new generations of characters based on the artist's observation and desire. The system allows the artist to select and save as many characters as he likes, and he can then initiate an evolving process to create new generation out of the selected population.

Storytelling is the representation tool in this research; therefore, an overview of literary fiction in terms of its meaning, features, forms, tools and basic elements is presented. One of the most important features and tools of storytelling is characterization which means the representation of the persons in the story. The success of any narrative work depends to a great deal on the writer's ability of creating memorable and unforgettable characters.

Digital storytelling has emerged as a new form that employs the powerful nature of digital media. It synthesizes multimedia based elements such as animated and still images, video, audio, music, and text to create engaging and compelling narratives. One of its distinctive qualities is interactivity which establishes a two-way communication channel between the medium and the reader. While a high level of interactivity gives users great control abilities, a lower level provides experiences closer and similar to those of traditional media. Another characteristic is emergence which is known as the ability of digital generating systems to generate and produce a wide variety of non-predefined stories that emerge from the interactions between the user and the system. Another important aspect is immersion which is the degree of involvement that the viewers/users have with the story due to the interaction that takes place between them.

A new form of arts that has emerged from the implementation of digital technology and computer science in art practices is generative art. The term is assigned to artworks created by employing a computer system, automated technology or algorithmic method. In generative storytelling, three approaches are usually used by authors and artists to generate narratives, which are plot-based, character/agent-based, and hybrid approaches. This research employs an agent-based approach as the core engine for creating and

generating both the characters and the narrative structure. The focus in this approach is on creating stylized and simple characters and not on the simulation of human behavior.

3 AN APPROACH TO GENERATIVE COMICS

Similarly to other fields and aspects of our life, comics have also been affected by digital technology. The creative community and many of the largest global companies such as Marvel are now using modern animation software tools to produce digital comics and graphical stories; they have even converted their old comics into digital formats. Moreover, portable display devices such as smart phones and tablet computers have almost become the main platform of consumption for comics, film, animation, games and other interactive visual media.

The employment of technology in comics goes beyond the use of digital assistant tools such as drawing software and devices. Computational methods have the potential to provide diverse and limitless possibilities in the creation of storytelling and comics. One of these possibilities is to employ the technology in structuring the story itself, so that the story can be generated by a set of rules incorporated in a computer program where the computer acts as a generating system and not just as an aiding tool.

Despite the proliferation of online platforms dedicated to education and communication, which often rely on comics, animations and other visual storytelling techniques, generative comics and visual narratives are still poorly studied in terms of their design and efficacy.

This chapter discusses this novel approach to generate comic narratives. It is divided into two sections: the first provides a review of related works and analyzes their types; the second describes the presented approach and discusses the generative system that is built to evaluate the approach and concepts.

3.1 GENERATIVE COMICS: REVIEW OF RELATED WORKS

The impact of digital technology on comics can be clearly seen in the various computerized tools that are used to design and visualize a variety of narrative forms. This impact led to the rise of interactive narratives and video games which have attracted academic researchers who focused on user interaction and content generation in the field of comics narratives. A significant part of

these researches has been dedicated to generating components of a narrative autonomously via the use of intelligent algorithms. Another part has focused on the use of digital tools, computer software and painting programs in the creation process of artworks, such as graphic drawing tablets and Photoshop [179].

In the field of narrative artifacts, some computer programs were specifically designed to provide the artist with multiple comics elements such as panels, gutters, splashes, and speech bubbles to choose from while producing the artwork. Others were intended to automate certain features of the authoring process such as plot, space, and characterization. In general, most of the computer applications and programs were intended for personal and entertainment purposes without any automatic production features; thus, the produced works cannot be described as generative art since they are manually created. This was also argued by Galanter [115] who stipulated the existence of some automatic features in the creation process for a work to be considered as generative art. Strip Generator and Comic Life are two examples of such editing programs.

By examining the existent research and works on generative comics in terms of the story structure and its visual representation, four categories have been identified: Unified Comics Generators, Comics Elements Generators, Visual Representation Generators, and Generative Comics Installations. These directions will be discussed briefly in what follows.

3.1.1 UNIFIED COMICS GENERATORS

The works produced within this direction focus on generating the story's main structural elements (plot, space, character) and its visual representation either autonomously or interactively through the use of various data processing methods. Some processing methods are quite simple such as random processing of graphical elements, while others are more complex and based on artificial intelligence techniques such as neural networks and evolutionary algorithms.

One of the works produced within this category is the work of Alves et. al., [51] wherein the computer application *FearNot* is used to generate an emergent, unscripted narrative, in which a cast of autonomous characters are created to produce logs that record bullying and ironic situations. An XML-based language called *Comic Strip Description Language (CSDL)* was

adopted in the editing process to define the critical actions in the log based on the emotional states of the characters.

Another approach is that of Martens et al. [180], which deals with the narrative's discourse structure as the primary goal. Based on discourse theories for comics by McCloud and Cohn, the project was able to produce a wide range of abstract comic output, and generate the panel contents based on notions of relatedness supported by the cognitive theories of visual language.

3.1.2 COMICS ELEMENTS GENERATORS

Comics has its own terminology and key elements such as panels, gutters, splashes, speech bubbles, captions, and sound effects that should be used to make any comics narrative stand out and be considered as an art form. Some works such as [44] and [181] focused on the computational generation of speech and thought balloons, others such as [45] explored the frame selection and panel generation.

In short, the works within this category focused on the generation of particular comics elements rather than the whole narrative and its discourse structure.

3.1.3 VISUAL REPRESENTATION GENERATORS: VISUAL SUMMARIZATION

Works within this category has focused on generating the content of the comics narrative. Some contributions have relied on other sources such as computer games and video streams, while others have generated the content from still images, events, exhibitions, conferences, daily records, or even chatting conversations between users. The *ComicDiary* system [182] is an example of the works that rely on users' actions and records. It generates the narrative content from the data of the user's records, diaries and interactions with other users who share the same experiences and situations.

The work of [49], which generates the story content from the screen shots of memorable user actions, is an example of the works that relies on computer games as a good source for generating comics content. A similar approach was followed in the work of [50].

Using video streams as a source of content can be seen in the *CORVIS* [46] and *Cinetoan* [47] systems. These systems generate the comics content from

the screen shots of important events after applying special comics effects to them. Similar approaches were followed in the works of [183] and [48].

3.1.4 GENERATIVE COMICS INSTALLATIONS

Since the inception of interactive narratives, artists have become able to present their artworks and comic strips in digital exhibitions where the audience can create or influence the dramatic storyline through their actions and contributions. In these interactive installations, the participant's portrait is incorporated into an algorithmic code-generated comic book where he/she becomes the creator and actor in his own comic strip. He/she can also fill with his own words blank speech bubbles that were added by the software to be incorporated in the narrative composition.

Ideogenetic Machine [184], is an example of such an interactive installation. The machine captures real-time images of the participants and directly transforms them into a “line-drawing” style portrait to be incorporated into previously line-formatted panels and blank speech balloons. Thus, a unique and non-repetitive comics story is generated through the participation of the viewer.

3.2 SYSTEM STRUCTURE

The approach of this thesis relies on integrating three layers of processing in the generative system, where each layer is associated with a specific part of the generative process, and the combination of these layers forms a coherent structure capable of generating and creating comic strips in an interactive procedure with the user. These layers are: a character-based environment that functions as the engine for generating storylines or story raw materials based on the interactions between the agents themselves and the environment they occupy, an interactive evolutionary process which allows for creating new generations of characters based on their parents' personalities and behaviors as well as the user's preferences, and finally a comics generative system that converts the generated story material to comic strips. Figure 2 shows an overview of the system structure.

The system user interface is easy to understand and shows clear information about the characters and their behaviors, as it provides the user with all the tools and controls he/she needs to perform the generating process; these tools and methods include modifying characters' genomes to influence their behavior, executing and controlling the evolutionary process, changing story

visual themes and the characters' designs, assigning personal attributes and traits to characters based on observation, and tools to create and design comic strips.

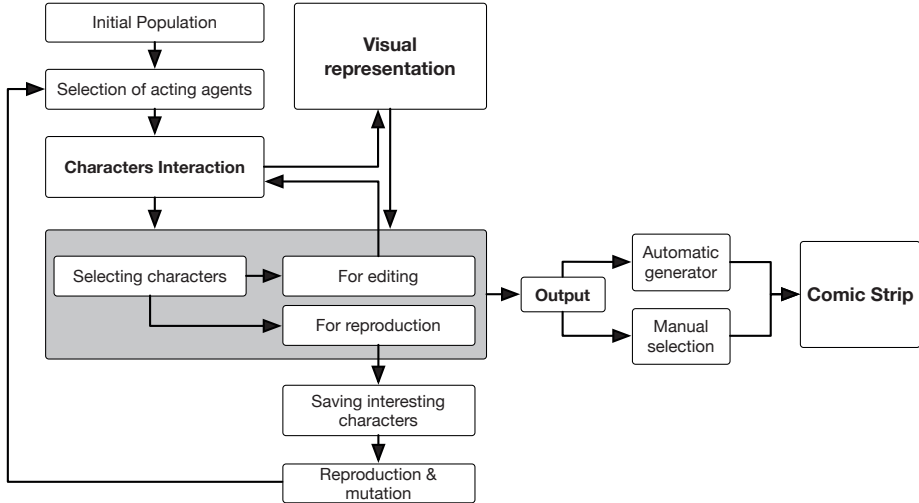


Figure 2. Flow diagram illustrating the structure of the system.

3.2.1 CHARACTER-BASED APPROACH

This section presents a brief description of the agent structure that allows the agent personality to be represented in terms of a dynamical system, where the changes in the internal states and the actions of an agent depend on its interactions with other agents. An agent is described by three different kinds of information: *internal states* which can be interpreted as moods or emotions, and can change in time during a simulation of a group of interacting agents, *genetic information* which can only change when agents are reproduced, and a set of pre-defined allowed *actions*.

The internal states of an agent take continuous values, so that they can represent, e.g., different levels of an emotion. They change dynamically during the interactions with other agents, and the changes in the internal states depend both on the actions of the agents toward each other, and on the genetic information of the agent, which may predispose it toward certain forms of behavior. In this way, different genomes result in different internal

state changes and actions for two agents subjected to identical situations. This forms the basic principle of the representation of agent personality. As mentioned in section 2.4, this approach to agent personality has some similarities, e.g., to that of [155], even though the representation used in this thesis allows a considerably wider range of unusual behaviors and personalities more relevant to comics.

The internal states can be grouped into three categories: *resources*, which are allowed to change as a direct result of the interactions with other agents (analogous to health points in a computer game); *emotions*, which are affected indirectly by the actions of other agents (through genetically determined functions that determine how an action affects an agent), and *feelings*, which represent attitudes or action tendencies that an agent has towards other agents. This may include feelings that the agent has toward itself (which could result in a character punishing itself or committing suicide out of self-contempt).

In most experiments, the behavior of groups of several agents is observed. The internal states are then updated when an agent performs an action, and when it receives an action from another agent; the state changes are in these two cases described by different parts of the genome. The number of internal states has in general been kept small, since even as few as two emotional dimensions can result in interesting personalities. The choice of comics as a representation tool makes this reasonable, since the characters generally have a simple and stylized personality.

The genetic information consists of a genetic encoding of functions that determine an agent's actions given the situation it encounters and its internal state, and functions that determine how the internal states of the agent change in the given situation. These functions are represented as strings of symbols or real numbers, to which one can apply standard genetic operators of evolutionary algorithms (see, e.g., [54]). Finding suitable parameterized representations of these functions is essential, so that the space of personalities can be searched in a systematic way. This is described in more detail in Studies I and III.

In the simplest version of the model, an agent's action depends only on its internal states and the identity of the agent with which it is interacting. There is no explicit dependence on previous actions between the two agents, but a memory may still exist in the values of the internal states. These could provide a record of previous actions in terms of positive or negative feelings

towards the other agent. More complex functions represented by larger genomes could also take the history into account.

Different kinds of search algorithms have been explored in the thesis. The simplest approach is to consider only changes of a single main agent, and to gradually adjust its parameters depending on observations of its interactions with other agents; this approach is adopted in study IV. Studies I and III include the implementation of an interactive evolutionary algorithm, where the artist provides the fitness function and carries out the evaluation and influences the evolution process. Initially, genomes are assigned randomly or copied from agents evolved in previous simulations.

Finally, each agent has a certain set of allowed actions toward other agents. In some simulations, the actions' labels were assigned freely, in others the labels of actions and states were inspired by original comic stories. Another choice is to decide on the interpretation later as part of the artistic process, e.g., through a stage of interactive evolution. One part of designing a story world consists of choosing the actions that the characters can carry out. These can be detailed and agent-specific, (such as Ignatz Mouse throwing a brick at Krazy Kat [185]), or quite general and allowing the artist to fill in details by hand at the end. The actions may also be defined to have a pre-determined effect on the resources of other agents.

We only consider pairwise interactions between agents, and actions are performed sequentially rather than in parallel. The order of agent interactions can be determined by selecting a random agent for interaction at each time step, or by letting an agent respond with some probability to encourage sequences of reciprocal actions. Sometimes we consider only pairwise interactions between a main agent and another agent; in that case, the agents perform alternating actions.

A simulation can be interrupted at any point in time by the artist, who may decide that it is appropriate to move on to a reproduction step to create a new generation of agents. This is described further below.

3.2.2 INTERACTIVE EVOLUTION

The process of interactive evolution allows the user to provide the fitness function for the evolutionary algorithm when generating new generations of characters; the method is considered to be valuable and effective in creative

and artistic works because they are subjective ones, and humans are much more capable, effective, and faster in evaluating artistic works than machines.

In this approach, the process of generating new generation of characters is initiated manually by the user; in this way, the user can choose to either use the method or not. For instance, some of the simulations in this research were performed by integrating and using the evolutionary method to create new characters, while in others the method was simplified, and the process depended on affecting characters' behaviors by modifying their genomes directly through a tool implemented in the user interface that maps the selected character's genomes onto a two-dimensional space.

In order to use the evolutionary method, the user needs to select and save some interesting characters to form a population of parents, then he/she can initiate a production process to create new characters from randomly chosen two parents, then the generated character replaces the protagonist in the story scenario automatically.

3.2.3 COMICS GENERATIVE PROCESS

The method of creating graphical elements for comic strips in the presented approach is fairly simple. A generated story is represented and shown as an animation in one region of the user interface; this animation shows a graphical representation of the characters and their environment in real time. The animation screen functions as the source of comics panels which can be created manually by capturing screen shots of the animation based on the user's observation. The user can then also decide the zooming factor of the shots, their sizes, and shapes. There is also an option to instead automatically generate a complete comic strip automatically, in which the panels are chosen by specific factors such as action type or a radical change of one of the characters' emotional states.

The graphical representation consists of both an environment and graphical designs of characters; the system offers the user several options of different themes of graphical representations which he/she can choose from. These representations are constructed from sets of smaller parts, which when combined in specific formations show different characters with different poses and expressions; this method allows for a small number of graphical elements to construct a variety of shapes and designs, as it allows the integration of different layouts and themes to represent different types of stories.

3.3 CHAPTER SUMMARY

Computational methods can provide diverse possibilities in the creation of storytelling and comics art. The majority of newly produced comics are created by means of a computer software and digital devices, where the computer acts as a generating system and not just as an aiding tool. Through a quick review of the works produced in the field of generative comics, four categories are identified: Unified Comics Generators, Comics Elements Generators, Visual Representation Generators, and Generative Comics Installations.

In this research, the presented approach relies on integrating three layers of processing in the generative system, which are: a character-based environment that generates storylines based on the interactions between the agents' themselves and with their environment, an interactive evolutionary process which procreates new generations of characters based on their parent' personalities and behavior, and a comics generative system that converts the generated story material into comic strips.

Agents are equipped with internal states that are grouped into three categories: resources which change as a direct result of the interactions with other agents, emotions which are affected indirectly by the actions of other agents, the current state of the agent, and its genome, and feelings that represent the emotions that an agent has towards itself and other agents. The agents have a small number of internal states in all simulations conducted, since interesting personalities can emerge from simple and stylized characters. This makes comics a reasonable choice of representation in this approach.

4 SUMMARY OF THE STUDIES

This chapter provides a summary of the overall system structure and methodology. The studies are divided into five topics; each topic concentrates on studying specific features and concepts of the presented approach. The last study, however, is an overview and analysis of other related methods and approaches in generative comics.

Table 1. Distribution of studies and conducted papers

Study #	Study Title	Paper #	Papers	Aim & description of the study
I	Interactive Approach for Generating Story Structures	1	Story characterization using interactive evolution in a multi-agent system.	Generating fixed narrative structures to be presented through a medium of the artist's choice; it provides the artist with narrative skeleton to be refined and developed into a final work
II	Character Development	6	Character in fiction: importance & development techniques.	Establishing a knowledge base about the nature and importance of character in literary narratives and providing better understanding of story characterization and character types.
III	Interactive Method for Story Characterization	2	Character evolution approach to generative storytelling	Investigating the possibilities of expanding the system to be used in designing and building characters; thus, the emphasis here is on the characterization process rather than on the story structure
		3	An interactive approach to story characterization	
IV	Generating Comics	4	Generative comics: character evolution approach for creating fictional comics	Exploring the implementation and employment of the results obtained from the theoretical research in the presented generative system
V	Analysis and Overview of Generative Comics	5	Generative comics: introduction and analysis.	Providing an overview and analysis of the conducted researches and works in the field of generative comics

4.1 STUDY I: INTERACTIVE APPROACH FOR GENERATING STORY STRUCTURES

This study investigates generative methods in storytelling and provides an overview of the conducted researches in this field. The study proposes an approach for generating narrative structure by combining two procedural methods: a multi-agent system and interactive genetic algorithms. This approach is implemented through a system that serves as a creative tool to assist artists in generating narrative structure and integrate their creativity into the generative process by allowing them to control and affect the evolutionary procedure of the system.

In this approach, the narrative structure emerges from the interactions between agents who are evolved into new generations by employing genetic algorithms in an interactive procedure with the artist. The reproduction process depends on the artist's opinion and his perception of agents' behavior; agents who show relevant behavior to the artist's goals are selected for reproduction, and the process is repeated until the artist is satisfied with the agents' personalities. The skeleton of the drama is generated from the interactions among the final ensemble of agents/characters.

The main focus of the study is on generating fixed narrative structures to be presented through a medium of the artist's choice; it provides the artist with narrative skeleton to be refined and developed into a final work.

4.2 STUDY II: CHARACTER DEVELOPMENT

The aim of this study, which is part of the theoretical foundation, is to establish a knowledge base about the nature and importance of character in literary narratives and provide better understanding of story characterization and character types.

The paper starts with reviewing the definitions of literature as the general incubator of the various literary forms. Then fiction as a literary form is discussed in terms of its purposes, motives, importance, essential elements, and approaches of writing. Afterwards a review of *character* as a major element of literary fiction is presented. Its importance is highlighted in terms of its being the foundation for any good narrative as well as the driving force that creates and moves the action and plot of the story. The most common types of characters used by literary authors are reviewed in terms of meaning, interpretation and different roles in the narrative process. Then

characterization as an important element to create life-like characters is explored in terms of meaning, importance and common methods. At the end, *character development* techniques are presented and reviewed in terms of meaning, importance and the most common tools employed by literary authors to create plausible and memorable characters.

4.3 STUDY III: INTERACTIVE METHOD FOR STORY CHARACTERIZATION

This study is a continuation of the first study presented in paper 1. While the first study focuses on the employment of the proposed generative system for generating story skeletons, this study investigates the possibilities of expanding the system to be used in designing characters; thus, the emphasis here is on the characterization process rather than on the story structure. For this purpose, the system has been updated to incorporate additional tools and functions that aim to simplify the generating process and provide the artist with more detailed feedback about the characters and their behavior.

Paper 2 focuses on creating completely new characters without any reference or association to existing ones; this is useful when the user of the system has no clues to the type of characters he intends to use for creating a story; in such case the system provides the artist with different options and a variety of character types to choose from.

In paper 3, which is the second paper in this study, the aim is to test the system through designing a character that reflects the personality of a well-known and existing one such as Donald Duck from Walt Disney Comics. Donald has been selected as a case study due to his simple personality and stylized structure that accommodates the simple type of characters relevant to this study; and consequently, assign him as an archetype for generative approaches in general and this study in particular.

The study results show that the system is efficient in this regard, and can in practice assist artists in creating their own desired types of characters for their generated narratives, as it can provide them with a broad range of possibilities and choices.

4.4 STUDY IV: GENERATING COMICS

This study explores the implementation of the results obtained from the theoretical research in the presented generative system. Paper 6, “*Generative comics: character evolution approach for creating fictional comics*” proposes a framework to create comic stories based on the methods described in previous papers. The generative system in this framework was developed and updated to provide more functionalities and controlling tools for generating final stories, such as adding another layer of procedure that allows the artist to create final and complete comics out of the system.

The system’s interface was redesigned to provide better experience and efficiency. It now includes several distinctive parts that aim to show visual and detailed information about agents’ actions and internal states as real-time graphs, render the emerged stories as animated cartoons to visualize agents’ behavior more clearly, and form the bases of the graphical elements for the comic representation. It was also developed to include control panels that allow the artist to make explicit changes in the genomes’ parameters of the agents, direct the reproduction process, and create comics in a semi-autonomous process with the artist.

In short, this framework takes advantage of the findings of the theoretical research through incorporating them into the generative system to create a final product that serves as an assisting tool for artists to build story characters, generate stories out of characters’ interactions and behaviors, and represent these stories in a comics format.

The focus of this study is on visual storytelling through the medium of comics. The findings of the study show that such methods can be useful and practical in creating interesting artworks that can be considered either as final artworks or works-in-motion to be manually developed later on by the artist himself.

4.5 STUDY V: ANALYSIS AND OVERVIEW OF GENERATIVE COMICS

This study provides an overview and analysis of the conducted researches and works in generative comics. It identifies four different - and sometimes overlapping - categories of generative comics, which are: integrated comic generator systems, comics’ elements generators, visual representation generators, and generative comics installations. The study discusses these

categories and presents examples of such generative comics created by other artists and authors, as well as providing suggestions and recommendations for future research and similar artistic works.

The aim of the study is to establish a knowledge base of the field of generative comics by studying and identifying its different categories, features, similarities, and differences as well as exploring the conducted works by researchers, scholars and artists of the field.

5 DISCUSSION

This chapter discusses the findings of the simulations carried out with the designed system, and reviews the results obtained from the studies. These findings are divided into three sections: the first focuses on the characterization aspect of the proposed approach and the personalities of the generated characters, the second focuses on the generated stories as a result of the characters' behavior, and the third is related to the visual representation of the generated comics story. Additionally, the discussion provides suggestions and recommendations for future work and studies.

5.1 REVERSED METHOD FOR DESIGNING CHARACTERS

Traditionally, the procedure of building story characters relies on a gradual development and step-by-step iteration. Consequently, the author is required to think carefully about the character's personality traits, behavioral aspects, cognitive skills, actions and reactions, visual appearance, and self-reflexivity.

This research proposes a different approach for building characters; it can be seen as a reversed way of the classical method. Instead of building characters step-by-step from scratch, which requires solid experience and intensive cognitive efforts from the author/artist, this approach provides the artist with several options and various character designs to choose from, reproduce, develop and enhance. This will reduce the complexity and difficulty of building characters, especially for new and amateur writers.

This approach does not replace the classical one, but rather complements it, as it does not profess by any means to be better than it, but rather proposes a different and new procedure of building characters, creating new forms of narratives, and disseminating new experiences of art making.

5.2 EMERGED STORIES

The generated stories by the proposed approach emerge from the actions and interactions that take place between the characters, which in turn fosters the fact that emergence is one of the most interesting features of generative art methods. Emergence presumes that the output of the generated artwork is unpredictable even from the artist himself. Such an output is capable of

provoking feelings of surprise and wonder from both the artist and viewers alike [93]. Unpredictability is an interesting feature by itself; even if the output is dissatisfying, it still has the potential to provide the author with diverse possibilities and wide range of choices. Such a feature is intrinsic to generative systems only and usually unattainable by traditional ones.

In the proposed approach, the emerged stories were unpredictable; they emerged from the dynamic behavior of agents that depended on several factors and parameters such as the complexity and size of agents' genomes, the extent and kind of actions that the agents were allowed to execute, and the capacity of agent's internal states. During all the simulations executed in this research, these parameters were kept as small as possible, which produced very simple and modest agents in terms of their structures and personalities. Consequently, the emerged stories were simple in structure and unpredictable in course and end. While simple agents are usually not expected to be life-like characters since they are intended to be employed in mimic situations and humorous context, the generated agents here demonstrated amusing personality traits and intriguing behavioral aspects despite their simplicity.

In general, complex characters with large action spaces and versatile internal states are more capable of producing surprising and unpredictable narratives; nevertheless, such a case makes the study of the systems' dynamics and the analysis of the characters' behavior a much more complex and arduous task, as it entails certain conditions that might be unsuitable for research and investigation.

5.3 VISUAL DESIGN OF THE GENERATED COMICS

Transforming the results of generative systems into appealing comic stories is a challenging work; there are many factors and elements that should be incorporated in the composition of comics panels. Some factors are directly obtained from the generative system itself, such as the characters' modes and feelings, and their actions and reactions towards themselves and others. Other factors are more complex to represent, such as reflecting characters' personalities properly into visual designs, determining camera angles and perspective views for the panels, reconciling the relationship and arrangement between foreground and background elements, and designing the panels' shapes, sizes and layouts. Such factors are associated with the use of comics features in the generative system, which can be achieved either by an automatic process, an interactive process, or a semi-interactive one. An automatic implementation can be difficult and complicated process,

especially when considering that these factors depend on subjective decisions that are taken based on artistic and personal taste, observation, and point of view. In contrast, an interactive process can provide better and more appealing results since it incorporates the human sense of judgment in the decision-making processes.

The graphical and pictorial elements of the comics representation can be created either through a 2-dimensional method, 3-dimensional one, or a hybrid of both. One way of implementing a 2D method depends on using vector or raster 2D images as elements to construct and compose the panels; it does so by taking the required images from a database and combining them in a systematic and coherent way. Another way is by taking AI based algorithms such as a neural network to generate pictorial images; however, this method is more complex and difficult to achieve since it is contingent on further developments and innovations in intelligent algorithms [186], [187] , [188].

The 3D method depends on the employment of 3D modeling engines, such as Unity [189], to create and compose the story panels by taking shots of 3D scenes. The 3D characters in such a case are reflections of the system agents, and their poses and actions are modified and updated according to agents' behavior. The 3D method has the potential to create wide variety of scenes and employ different camera angles and cinematic views; nevertheless, such modeling applications have been used to create classical comics rather than drawing them.

In this approach, a simple 2D method is employed, in which the characters are constructed by combining several pictorial parts together. Through this procedure, it is possible to produce a wide variety of visual designs and complete images/panels from a limited set of pictorial elements.

Camera angles, scenes' composition, panel sizes, and page layouts are defined and designated by the artist who selects the events and scenes that will be used in the comics story and chooses the appropriate page layout from a list provided by the system. The system then incorporates the selected scenes in the page layout to create a final comics page.

The simulations showed that this method is acceptable for stylized and cartoonish representations where the characters are simple in their visual appearance, and the cinematic views are quite limited. Using a similar method for constructing more realistic characters requires a much larger database of pictorial elements and more extensive utilization.

5.4 FLEXIBILITY AND FUTURE SUGGESTIONS

While the presented approach aims to generate printed forms of comic stories in its final stage, the constructed system and the conducted simulations show that it is associated with high flexibility that entitles it to be used in various ways for different applications. Currently, the dividing lines between video games, interactive stories, and interactive comics are imperceptible, undefined, and misleading because they have many features and attributes in common, and there is almost no clear way to specify the category into which a particular work fits.

Interactivity is a central characteristic of the various forms of digital storytelling since they all share the main goal to deliver stories in an immersive and engaging way for a distracted audience in an accelerating and overly connected world. Generally speaking, interactivity as a tool can be used in various fields such as authoring, education, entertainment, and training. In storytelling, it can be classified in terms of its ultimate goal or essential objective into two types: author interaction through which the author creates the story world with its setting, characters, plot, and theme, and user (reader/viewer/player) interaction through which the user experiences a unique story based on his/her interactions with the story world [190].

In the presented approach, interactivity is used as a tool by the author or artist to create comic narratives, in a similar way to that of a word processor. However, the approach can be easily adapted for other applications such as video games, animation, gag cartoons, and interactive storytelling, as it can be used for pure entertainment, education, and training. In short, the potential value and efficacy of this approach is wide due to its flexibility, scalability, competency, and capability to be employed in various applications for different purposes.

In study V, the generated stories that emerge from the agents' interactions are represented as real time cartoon animations and comic strips in which the agents express their internal states through their facial expressions and body gestures. However, the simplicity of these particular visual representations has great impact on the visual rhetoric of the created comics; this can be significantly improved by the inclusion of more qualities and features of comics such as different panel layouts, better encapsulation, and cinematic views, e.g., view angles, perspectives, and close-ups.

One of the main purposes of the proposed approach is to assist authors and artists in their task of creating simple fictional characters. Nevertheless, being particularly concerned with the creation of simple and stylized characters does not mean that it is not applicable for designing complex characters with rich personalities. The characters' appearance can also be improved by including interactive algorithms to assist the process of their visual design, so they represent agents' personalities beside their internal states. Other features that can be added in future developments include the use of new tools for supporting the creation of visual representation of characters, and incorporating an interactive algorithm for evolving transformations from abstract design representations to semantically meaningful visual renderings.

5.5 CHAPTER SUMMARY

The findings of the designed system are discussed in terms of characterization and the personalities of the generated characters, the generated stories as a result of the characters' behavior, and the visual representation of the generated comics story.

Traditional characterization builds story characters from scratch through a step-by-step process, which requires solid experience and intensive cognitive efforts from the author; in contrast, the presented approach provides the artist with several options and various character designs to choose from, reproduce, develop and enhance.

The generated stories in this research emerged from the dynamic behavior of agents that depended on several parameters such as the complexity of agents' genomes, the kind of actions that the agents were allowed to execute, and the capacity of agent's internal states. These parameters were kept as small as possible which produced very simple and modest agents in terms of their structures and personalities. Consequently, the emerged stories were simple in structure and unpredictable in course and end.

The graphical and pictorial elements of the comics representation can be created either through a 2-dimensional method, a 3-dimensional one, or a hybrid of both. In this approach, a simple 2D method was employed, in which the characters were constructed by combining relevant pictorial parts together. Through such a procedure, it is possible to produce a wide variety of visual designs and complete images/panels from a limited set of pictorial elements.

The constructed system showed a high flexibility that entitles it to be used in various ways for different applications. Furthermore, the interactivity feature was used as a tool by the author to create engaging comic narratives, in a similar way to that of a word processor. The potential value and efficacy of this approach is wide due to its flexibility, scalability, competency, and capability to be employed in various applications for different purposes.

One of the main purposes of the proposed approach is to assist authors and artists in their task of creating simple fictional characters. Nevertheless, being particularly concerned with the creation of simple and stylized characters does not mean that it is not applicable for designing complex characters with rich personalities.

6 CONCLUSION

In the current digital era, technology is permeating our lives, and our dependence on it is increasing on a daily basis, leading to new modes, lifestyles and experiences, and calling for new revisions, assimilations and adaptations in almost every sphere of life. However, the degree and importance of these adaptations differ from one sphere to another; it might be vital in a given field and inessential in another. In the case of creative works and visual arts, practitioners have no option but to continually adapt their styles, techniques, and tools to accommodate the era in which they live if they want to be creative contributors to their society and culture; otherwise, they will be, but the primitives of this digital era.

Throughout its history, art has had a great number of different functions, purposes and reflections; making it difficult to favor one art form over any other. Each form of art has its unique functions and goals, as it seeks to provoke and reflect different emotional responses and cognitive perceptions. That is so because represents the humans with their varying emotions, intellectual abilities, inclinations, desires, and needs. Hence, new forms of art do not by any means replace old ones, but rather complement them towards the perfect reflection of the volatile human nature. Consequently, digital technologies and generative methods in arts are not necessarily better than classical approaches, but still, they are new tools and techniques that deserve to be explored and experimented with.

In the last few decades, generative art and comics have started to attract the interest of researchers, scholars, and artists as two promising creative fields that are steadily progressing towards new cultural and creative spaces. Generative art was influenced by the digital revolution that started in the second half of the 20th century, and is still ongoing driven by the accelerating developments and innovations in digital technology. Likewise, comics took advantage of digital technology and returned to attract the attention and enhance its reputation as a powerful tool for education, communication, training, and entertainment.

Generative art is a method of creating art through or by the aid of autonomous systems. The reasons behind the artists' inclination and eagerness to employ generative techniques in their artworks is completely subjective and contingent on the artist's intentions, ultimate objectives and motives [115]. However, generative art leads to artworks that are associated with interesting and compelling concepts such as unpredictability and

surprise, as it has the ability to simplify, accelerate, and enliven the process of art creation.

Comics as a form of art has had a derogatory reputation for much of its history, holding them as a childish, humorous, trivial and low type of narrative. But towards the end of the 20th century, it started to gain greater public and academic acceptance thanks to the artworks of creative and influential artists and writers such as Will Eisner, Scott McCloud, Frank Miller, Dave Gibbons, Neil Gaiman, and Alan More to list a few. These and other artists proved that comics is not just about funny animals or guys in spandex hitting each other, but rather a unique medium of storytelling and art form that holds great potential for procreating creative and exquisite artworks. Furthermore, the intrinsic features, distinctive qualities, and potential abilities of comics as a medium of storytelling, communication, and visual art make it suitable form of representation in various fields of education, training, entertainment, and communication. However, the use of digital and artificial technology in this approach is not intended by any means to replace human creativity, but rather support it and expand its horizons towards new forms of arts.

A large component of art practice is the quest for new ideas, methods, materials, and equipment for creating art works. We now have tools that can help us simplify our tasks and expedite our development, thanks to digital technology. The research questions of this contribution pivoted around this central concept, and the study tried to answer these questions through presenting and implementing an approach to generating comics through building and using a system that consists of three layers: a multi-agent system, interactive evolution, and a comics generating engine. Another contribution of the study towards the answers of the research questions is the simplification of the story characterization process, where characters are suggested rather than designed from scratch as it is followed in the traditional style of characterization. It also presented an unconventional way that integrates between human's creativity and machine's ability in the process of producing comics, where the machine becomes a co-artist and not just a standard tool for drawing, coloring or publishing.

Through the presented approach, the strengths of generative systems and comics are joined and integrated to form an amalgamation that aims to generate new approaches to storytelling and support artists in conveying their messages and achieving their goals. Though the study cases and conducted simulations are kept simple, they still show that such an amalgamation between generative methods as procedures and comics as representation

medium is highly promising since both fields are perfectly compatible with each other.

The study also shows how to build a framework that supports human creativity in fictional characterization and creates comics through a process of interaction with the user. It furthermore focuses on studying simple agents that have a plain structure in terms of their internal state and personality, and argues that they are particularly relevant to the creation of cartoons and comic strips, where simplified and exaggerated actions and personalities are commonly used for illustration purposes. Moreover, the constructed approach is multifaceted and shows a high flexibility that qualifies it to be used for various purposes in different applications such as video games, gag cartoons and interactive storytelling.

After all, images and pictures on their own merits usually contain fabulous amounts of meanings that words can never describe. To this end artists are permanent travelers through the divergent paths of inspiration, imagination and innovation, looking for new tools and techniques that enable them to embody and exemplify these meanings, express their emotions and perceptions, reflect their culture and society, and expand people's cognitive abilities, imagination, openness, knowledge and perception. Generative comics do have the qualities and intrinsic features that entitle them to play this significant role and be the perfect tool in this regard; thus, they are worthy of further investigation and profound exploration.

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APPENDIX

This appendix shows some examples of the system’s output; these comic strips were generated by the system in an interactive process in a semi-automatic manner. Different themes were used to create various visual character designs and environments. Themes are basically collection of pictorial images and fragments; the system combine the related images to construct the visual appearance of the characters and their environment based on their internal states and actions.







