O_HAI(4)Games

Orchestration of Hybrid Artificial Intelligence Methods for Computer Games

Case Study 2 - Cognitive Agents & Gamification

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Some of the results presented in this deliverable have been published in [99, 110].

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1. Project Description

1.1 Abstract

Hybrid artificial intelligence (HAI) methods, which can be defined as the orchestration of complementary heterogeneous both symbolic and statistical AI methods to acquire more precise results, are omnipresent in contemporary scientific literature. Still, the methodology of developing such systems is in the most cases ad-hoc and depends from project to project. Computer games have always been connected to the development of AI. From the earliest chess minmax algorithm by Claude Shannon in 1949 to the more recent AlphaGo in 2015, computer games provide an ideal testing environment for AI methods. Similarly, AI has always been an important part of computer games, which have often been judged by the quality of their AI and praised if they used an innovative approach. Computer games allow us to test AI methods, not only for fun and leisure, but also for numerous other fields of human activity through the fields of serious games and gamification. The project proposes to establish a new framework for the orchestration of hybrid artificial intelligence methods with a special application to computer games. Therefore an ontology of hybrid AI methods as well as a meta-model shall be developed that would allow for creating models (ensembles) of hybrid AI methods. This meta-model would be implemented into a modular distributed orchestration platform which would be further enriched with a number of modules to be tested in four gaming related environments: (1) MMORPG games, (2) gamified learning platform, (3) serious game related to autonomous vehicles and (4) a game for a holographic/volumetric gaming console which would also be developed during the project.

1.2 Introduction

The application of HAI which can be defined as the orchestration of heterogeneous artificial intelligence (AI) methods including both statistical and symbolic approaches in various domains is omnipresent in current scientific literature. It is largely overlapping with the term hybrid intelligence (HI) that has been defined as *"the combination of complementary heterogeneous intelligences (...) to create a socio-technological ensemble that is able to overcome the current limitations of (artificial) intelligence."* [22]. HI lies at the intersection of human, collective and artificial intelligence, with the intent of taking the best of each.

There have been numerous studies recently addressing issues related to HAI and HI methods in a multitude of application domains including but not limited to land-slide prediction [61], drug testing [15], forecasting crude oil prices [119], prediction of wildfire [45], evaluation of slope stability [53], modeling of hydro-power dam [14], wind energy resource analysis [31], industry 4.0 and production automation [9], airblast prediction [5], heart disease diagnosis [68] and these are just a few references from 2018 until the time of writing this proposal. Most of these and such studies report building HAI systems by combining various AI methods to acquire better and more precise results. However, when it comes to methodology of the actual orchestration of HAI methods the usual approach is ad-hoc and depends from project to project. The lack of methodology in orchestrating HAI shall be addressed in the proposed project.

In a previous project sponsored by the Croatian Science Foundation (Installation Project No. HRZZ-UIP-2013-11-8537 entitled Large-Scale Multi-Agent Modelling of Massively Multi-Player On-Line Playing Games - ModelMMORPG - see [106] for details) a comprehensive methodology for modelling large-scale intelligent distributed systems has been developed that includes a graphical modelling tool and code generator (described in [105] and in more detail in [82]). The implemented toolset allows for modelling complex multi-agent organizations and could be applied to numerous applications domains [101, 102]. Herein, we would like to apply and incorporate this methodology to the development of the HAI orchestration platform.

Computer games have always been connected to the development of AI. From the earliest chess minmax algorithm by Claude Shannon in 1949 to the more recent AlphaGo™ in 2015, computer games provide an ideal testing environment for AI methods. Similarly, AI has always been an important part of computer games. Computer games have often been judged by the quality of their AI and praised if they used an innovative approach like the ghosts in Pacman™ which had individual personality traits (1980), Creatures™ which used neural networks for character development (1996), Black & White™ which used the belief-desire-intention (BDI) model (2000), F.E.A.R.™ which used automated planning algorithms (2005) and many others (see [123, pp. 8–15] for a very detailed overview). Artificial intelligence in games is not only used for non-playing character (NPC) or opponent implementation, but also for various other parts of games [123, pp. 151–203] including but not limited to **generation of content** (graphics including levels and maps, sound, narratives, rules and mechanics or even whole games like the Angelina game-generating system [18]), **player behaviour and experience modeling** [123, pp. 203–259], as well as **bot development and automated game testing** [123, pp. 91–151]. Due to their complex nature and endless possibilities of creative design, computer games present us with an excellent opportunity to study the orchestration of HAI in various scenarios – not only for fun and leisure but also for other domains in form of serious games and/or gamification.

In the previously mentioned ModelMMORPG project, we have already used an open source massively multi-player on-line role-playing game (MMORPG) called The Mana World (TMW) for which we have implemented a high-level interface to test intelligent agents playing the game. Additionally a number of connected game quests have been developed for various scenarios which allowed us to build an automated game testing system [104]. Herein we would like to use this interface to test orchestrated HAI methods, but also develop other testbeds for the planned platform.

Therefore, the main contribution of the proposed project shall be: (1) a comprehensive framework for the orchestration of hybrid artificial intelligence methods for computer games allowing to define models of HAI for various purposes, (2) an open source distributed cloud platform that will allow to implement such models based on existing HAI methods and connect them directly from game development platforms, (3) a set of best practices in developing HAI ensemble models tested in at least four specific testbeds described bellow.

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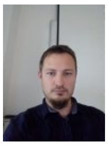

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2. Gamified Cognitive Agents for Telemedicine

2.1 Introduction

Cognitive agents represent intelligent agents which use various types of AI methods in order to allow interaction and learning from humans [55]. Such methods might include speech to text (STT) and text to speech (TTS) technologies, machine learning (ML) and deep learning (DL) models, natural language processing (NLP), BDI models, knowledge bases (KBs) as well as system automation. Cognitive agents have been used in numerous domains including but not limited to mental health therapy [112], Internet of things (IoT) and fog computing [30],education [11], home service robots [116], cognitive radio [74] and many more.

The art and science of gamification has raised major interest from both academia and industry [95, 100, 115]. We usually define gamification as "*the use of game design elements in nongame contexts*" [23, 42], and in a broad sense can be considered a successful motivation technique, supporting user engagement and enhancing positive behavioral patterns on various services like increase of activity, quality of work, socialization and hence productivity [37].

The World Health Organization (WHO) defines telemedicine as the "*delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities*" [120]

The basic idea behind this chapter is to argue the possible use of cognitive agents and gamification practices in telemedicine. In this context, we will firstly provide an overview of related work in section 2.2. In section 2.3, we introduce the Beautiful ARtificial Intelligence Cognitive Agent (B.A.R.I.C.A.) cognitive agent system that we have developed for student support. Then, in section 2.4, we establish a proposal of a framework that combines cognitive agents, gamification practices and telemedicine. In section 2.5, we discuss possible use-cases and implementation issues. In the end, in section 2.6, we draw our conclusions and provide guidelines for future research.

2.2 Related Work

The key feature [19, 120] setting telemedicine apart from the concept of conventional medicine is the fact that the relevant parties are separated in either space or time, or both. Craig and Patterson [19] further state that telemedicine episodes can be classified based on the type of interaction, and on the type of information transmitted during the episode. The agent discussed in this chapter is aimed to provide synchronous real-time interaction, thus providing immediate feedback to its users, where possible, as opposed to providing feedback in an asynchronous manner. Considering the nature of information being transmitted, one of the aims of this agent is to communicate with their users using a voice interface, possibly aided with a visual interface.

Use of AI is observable in many a major and minor area of human life and many services of the modern society [102]. In the context of telemedicine, according to Pacis, Subido, and Bugtai [84], trends in using AI can be observed in the domains of patient monitoring, organising and managing health records, intelligent assistance and diagnosis, and information analysis and collaboration, to name a few. Arguing in the broader context of telehealth, Kuziemsky et al. [54] recognise two main areas where AI is utilised: quality improvement for existing clinical practice and service delivery, and development and support of new models of care. The importance of telemedicine, and the quality of the services it provides, is especially emphasised by the ongoing COVID-19 pandemic during which there is an observable increase in telemedicine episodes [29, 52]. The prospects of AI in telepsychiatry, as a subclass of telemedicine, are discussed in detail by Thenral and Annamalai [113].

As a form of AI in the context of telemedicine, chatbots are used for: mitigating the severity of panic disorder [81]; weight loss [40] and promoting healthy living [89]; providing social and emotional support [118]; holding follow-up conversations with patients [57]; delivering a self-help program for college students who self-identify as having symptoms of anxiety and depression [28]; helping prevent suicide and self-harm [39]; providing primary healthcare education, information and advice to patients [12]; caring for discharged elderly patients living in rural areas [27]. Some chatbots are granted a detailed character and a physical appearance in order to make them easier to be adopted by their intended patient group [64].

For a comprehensive review of chatbots and their features, in the context of mental health, the authors would kindly advise the reader to consider [1, 75].

Artificial intelligence is utilised in other forms in the context of telemedicine as well, such as a smart mirror for monitoring elderly and their emotions [108], or an ambient assisted living environment consisting of robots and sensors, aimed mostly towards the older population [65, 88].

Naturally, when information systems and applications are considered in the context of medicine, even more so in the context of telemedicine, it is vital to consider the importance and implications of ethical aspects of the involved data [4, 107, 111].

One of the mechanisms utilised by the chatbot presented in this chapter, that is aimed at increasing patient engagement with the chatbot, and the efficiency of telemedicine visits, is gamification. The ideas of gamification can be applied to various activities performed in many areas of the modern world. Roca et al. [92] argues that gamification is one of the main management societal innovations introduced by the IT-revolution, and that utilising gamification policies is well known for achieving the following: power, stamina, innovation, bonus points, and level up. Furthermore, gamification is discussed by Jansson, Koivisto, and Pikkarainen [46] as "*an opportunity to increase engagement in a given health behaviour and, eventually, the possibility of reaching improved outcomes through continued or consistent behaviour.*"

Although a substantial body of research exists on the gamification techniques applied to elderly care [69], only a limited amount of information is available on the methods and success of using gamification in the context of engaging the elderly telemedicine users in particular [24]. Recently, Kalhori [47] argued towards some necessary structural requirements for successfully using telemedicine with the elderly.

2.3 B.A.R.I.C.A. Cognitive Agent

The B.A.R.I.C.A. cognitive agent system's software architecture is shown on Figure 2.1. It consists of a cloud-based back-end and an on-site front-end.

The cloud-based back-end being part of a larger framework being developed by the O_HAI (4) Games project (Orchestration of Hybrid Artificial Intelligence Methods for Computer Games) has already been reported in [98, 103] (an initial implementation concept has also been given in [97]). It consists of a microservice orchestration platfrom based on holonic multi agent systems (HMASs) [93]. Its components are:

1. A back-end application programming interface (API) which allows connecting various microservices including but not limited to knowledge and databases, AI related modules and external services.
2. A controller which acts as microservice orchestration system that allows connecting these various microservices into a coherent system.
3. A front-end API which allows for the implementation of front-end applications one of which is the B.A.R.I.C.A. front-end.

2.4 Framework Proposal

In the following, we present a cloud based telemedicine framework that is focused on the integration of AI (especially cognitive agents) and gamification into telemedicine. Figure 2.2 provides a high-level overview of the proposed framework.

The model subsumes four types of users:

1. **Physicians and specialists** – providing medical advice and data to other system clients.
2. **Patients** – the end-users.
3. **Nurses / Technical assistants** – providing patients with technical assistance and common procedures.
4. **(Client) physicians** – using the system to get assistance and data from specialists.

These types of users can use any Internet enabled device to access the platform including smart phones, personal computers, laptops or smart television sets to get various types of services depending to the implemented and orchestrated microservices of the platform.

The platform's conceptual model is shown on Figure 2.3 [98]. The orchestrated AI gamification platform provides interfaces that can be accessed by various types of client applications including gamified web and mobile systems implemented. The platform is an application framework that allows for building various AI and game oriented ensembles by orchestrating existing microservice templates into meaningful applications. These templates include various AI methods that can be tailored into microservice instances like concrete ML models, expert systems, finite state machines (FSMs), chatbots etc.

The platform is descibed in more detail in [98] and is the basic underlying back-end of the B.A.R.I.C.A. cognitive agent. Its mayor application area is the creation of services for various game engines and gamified platforms, but can be used for any type of microservice oriented applications. It is based on a holonic multiagent systems (MASs) architecture [36] in which individual microservices are represented as agents whilst ensembles are represented as holons. For the sake of telemedicine applications the framework can be extended with various microservice instances needed for the specific telemedicine oriented applications and services.

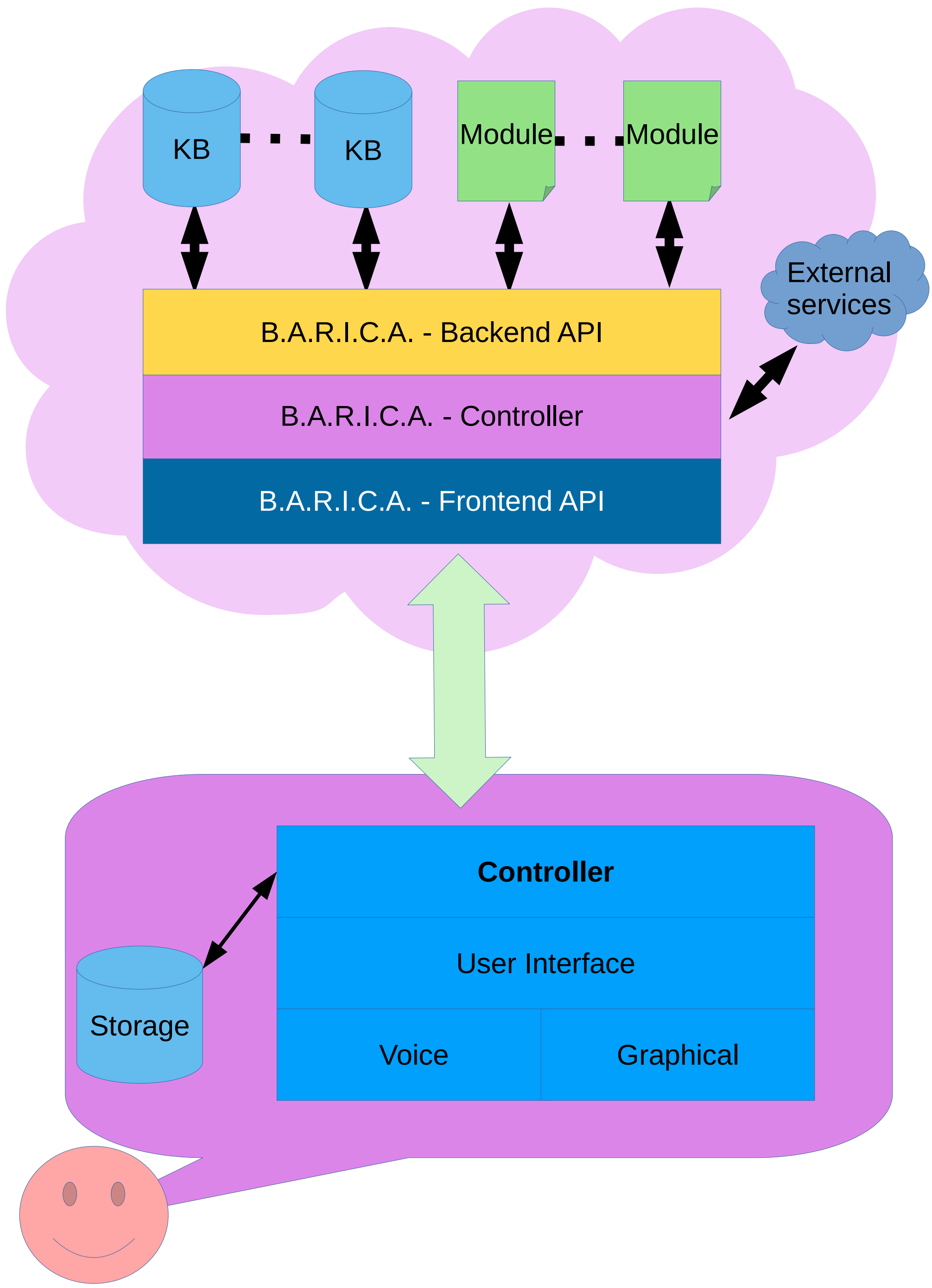

Figure 2.1: B.A.R.I.C.A. software architecture [96]

Figure 2.2: Conceptual System Model

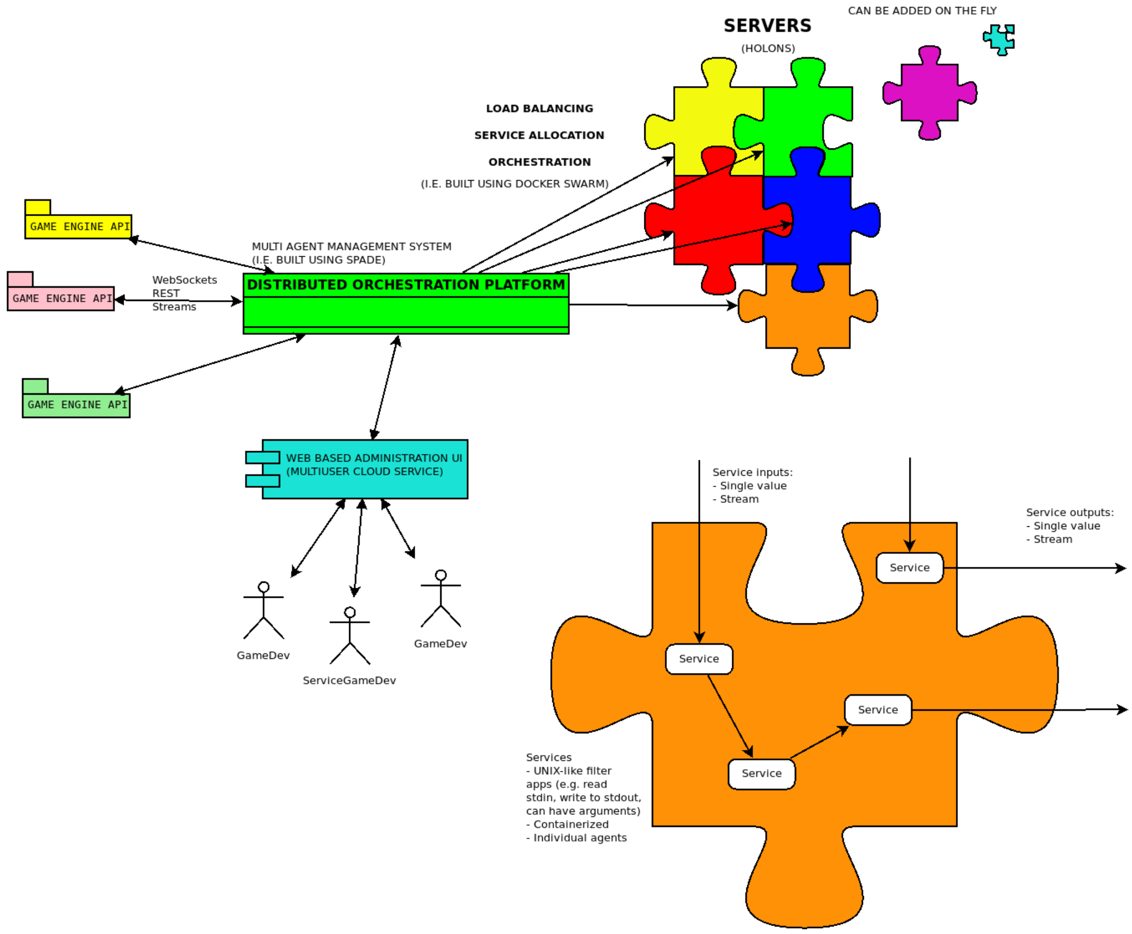

Figure 2.3: High-level Conceptual Platform Model

2.5 Use-cases and Implementation Guidelines

In the following, we present a number of potential use-cases for cognitive agents in telemedicine that could be implemented using the described platform as well as guidelines for gamification where possible. The use-cases have been compiled based on a literature and policy review.

AVATAR therapy or treatment of distressing voices with Audio Visual Assisted Therapy Aid for Refractory auditory hallucinations [20] which is based on using virtual avatars that are associated by patients with some aspects of their disease could be implemented using cognitive agents in which these agents would provide a virtual instance of the avatar. Such cognitive agents would have to be adaptable (learning) in order to absorb the various aspects that are associated with them, monitor progress and reproduce it when needed.

Chronic disease management and prevention including but not limited to asthma [33], allergies and the reaction to anaphylactic shock [109], diabetes [71], chronic kidney disease [59], acute coronary syndrome [80] are a potentially fruitful application domain. For the most of these chronic diseases, there are established and very detailed guidelines for various procedures which have to be performed on a regular basis. Some of these procedures can be performed by the patients and there are already a number of products including mobile phone applications which ease the daily routine. Most of these routines could be gamified by using a number of gamification techniques like virtual avatars, history of disease statistics, quests and similar; or could even be implemented as games in which a patient (player) advances through the game by applying the adequate procedures.

Prevention programs allow for the diagnosis in the earlier stages of a disease, which increases treatment options and overall survival in leading causes of death including lung cancer, breast cancer, cervical and colon cancer [121]. Cognitive agents and educational games could be used to raise awareness and encourage people to participate in preemptive examinations. For example, a cognitive agent that implements an expert system about the possible symptoms of a disease could answer questions and provide guidelines for a needed examination.

Protection and promotion of breastfeeding. Similarly to the previous use-case, a lot of countries has implemented national programs for the protection and promotion of breastfeeding ([21] for example). Again, by using cognitive agents and educational games, such programs could gain traction and reach a higher number of participants.

Emergency call reception. There are emergency call reception protocols defined for operators ([77] in Norway for example) which define detailed procedures, questions and control points. An operator could be assisted by a cognitive agents which listens to the conversation and provides suggestions based on reception protocols, thus reducing human error. This cognitive agent could be gamified using various elements like instant feedback loops to foster learning and reduce reaction times.

Protocol on treatment and protection against heat is a set of rules and guidelines on how to prepare, behave, and act in case of an impending emergency due to a heat wave, applicable to the national and local levels [72]. An integral part of the protocol are risk mitigating guidelines as well. A proactive agent could be used to notify and alert their users of a possible or incoming heat wave, provide them with suggestions on how to act and reduce the risk of being exposed to the heat wave. The rules might be gamified and e.g. badges rewarded for successfully following them, while users might be notified if there are experts or experienced players in their neighbourhoods.

Guidelines for treating patients with COVID-19 are to be used by infectiologists who are working on treating patients diagnosed with COVID-19. Such guidelines [10] are being defined worldwide, and are customised and adapted to the particular situation in a particular geo-political area. Although the number of end-users (the infectiologists) is limited, the guidelines could be modelled as a gamified process, possibly with suggestions on how to help a patient based on their state, and the staff might keep a score based on the number of patients they treated.

Control of antibiotic resistance is a set of guidelines [44] and recommendations on how to behave while consuming antibiotics, when to consume them, and when to prescribe them, how the consumption of antibiotics affects the resistance of bacteria, etc. The main goal of these guidelines is to preserve the effectiveness of antibiotics. Gamified guidelines combined with a virtual avatar of patients with specific personal stats that change in accordance with the behaviour of patients, where positive behaviour is boosted, and negative behaviour is discouraged, along with quiz-enriched educational games accompanied by a simplified simulation based on the life of bacteria and their reaction to antibiotics, might prompt the patients to re-think their bad habits or encourage their good habits in the context of antibiotic consumption.

Using automated external defibrillators (AEDs) is no easy task. AEDs installed in public urban places such as stations, stadiums, airports and similar, is a Croatian national program [73] that aims to educate and enable citizens to use public AEDs in case of emergencies and possibly save a fellow citizen's life. Before using an AED, a player might be guided through a set of steps that must be followed in order to assess the state of the unfortunate person, with points awarded by an on-site expert if the steps were followed correctly. Educational games could educate citizens on how and when to use an AED, or how to recognise a situation where an AED should be used.

Colonoscopy diagnostic procedure is a set of rules that aim at preparing the patient for an oncoming scheduled diagnostic procedure, e.g. colonoscopy [51]. Rules of such a protocol can be translated into achievements that should be unlocked on a path towards the ultimate award – taking part in the diagnostic procedure.

2.6 Conclusion

In this chapter, we have introduced an initial attempt at using cognitive gamified agents in telemedicine. We have introduced our microservice orchestration platform which might act as a backbone for the implementation of such applications. We have also described the B.A.R.I.C.A. cognitive agent which has been implemented for university student support and is partially based on the mentioned platform. We have argued that a similar approach can be used in telemedicine.

Afterwards, we have introduced a high-level conceptual model of an orchestrated AI gamification platform for telemedicine systems. The platform allows for the implementation of numerous microservice instances based on existing microservice templates which then can be orchestrated to create meaningfull applications and services. In the end, we have demonstrated a number of use-cases in which such a platform could be used in order to provide better telemedicine services to patients, physicians and technitians.

Our future research will be aimed on the actual implementation of some of the provided use-cases using the orchestration platform.

3. Automated Educational Game Design

3.1 Introduction

Educational games can help people learn disciplinary knowledge. Games also provide new theoretical models for disciplinary research, such as game theory in economics, operations research, finance, regulation, military, insurance, retail marketing, politics, conflict analysis and energy. Although, it has not been discussed much, games may also represent knowledge. Just as visual representations (diagrams, photographs and videos) provide certain unique informational advantages over text alone, perhaps game interaction provides unique informational characteristics to represent knowledge that text and non-interactive visuals do not.

As a simple example, in chess the situation where any move is a bad move, but the player is forced to move, is termed *zugzwang*. This concept might be a metaphor in other fields, such as military science or political science. However, educational games alone are currently important burgeoning resource. The need for AI to automatically design and generate educational games can be concretely illustrated by several case studies.

3.1.1 IMapBook

To address the literacy crisis and decline in children's recreational reading, one of the authors invented a new form of book, IMapBook [32], that adds games and social interaction into web-based eBooks. Students read pages of text, come to a game that can only be won by comprehending the previous text, then read on. Teachers can monitor student's progress in eBooks, and form student discussion groups. Student discussions can be monitored in real-time by teachers. Additionally, teachers can use an administrative system to download a variety of reports on students' progress.

With some seven high-impact, peer-reviewed journal publications, numerous dissertations, studies conducted in five different countries and occasional use in school systems, IMapBook has been a moderate success. However, the ultimate goal for IMapBook is for it to be used by a large number of educators and students, at least in the hundreds of thousands.

As in the educational games movement at large, the bottle neck with IMapBook is the skills, resources, time and money needed to create high quality educational games. In the first couple of years, IMapBook researchers created arcade-style games, where a core educational need was

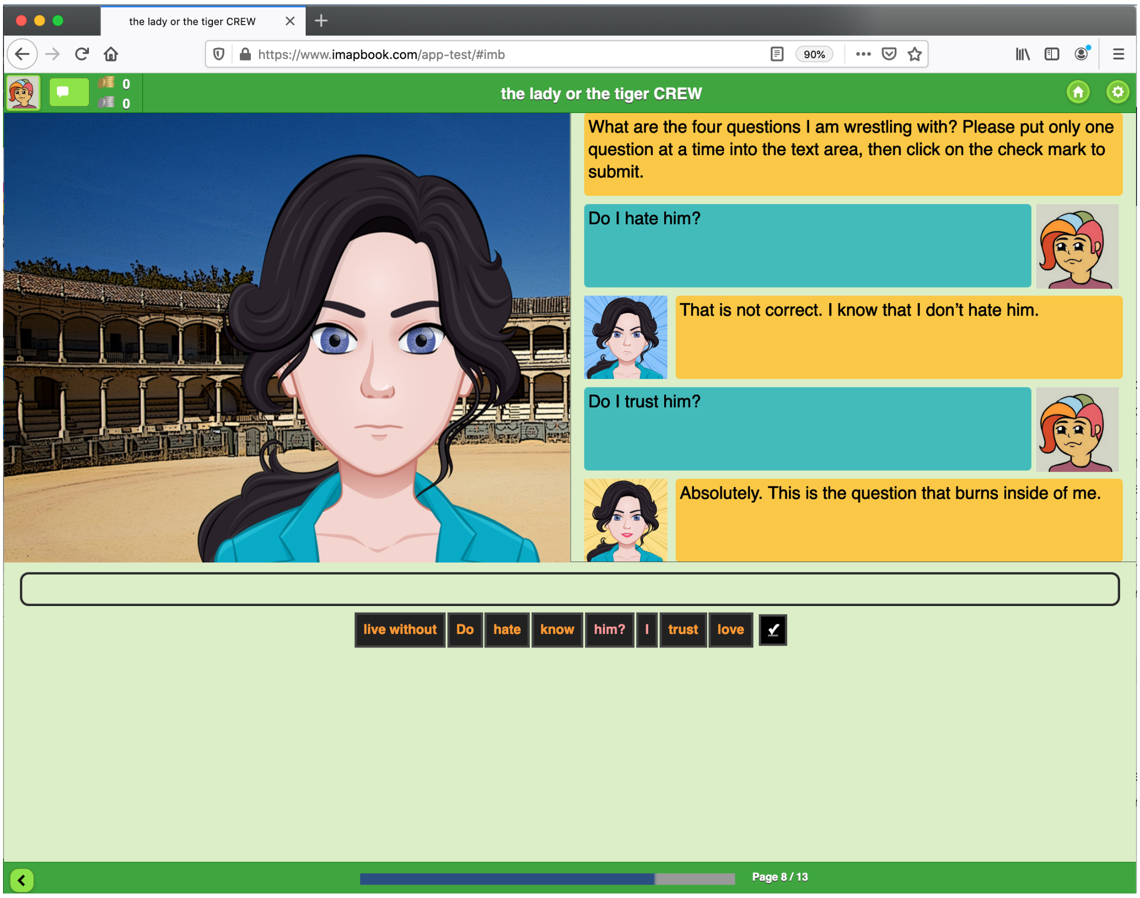

Figure 3.1: Screenshot of a conversation with a character game in IMapBook

morphed into a game mechanic and then, with iterative improvements, into eBook with games that worked well in classrooms. This required astute instructional designers, programming expertise, artists to produce assets and the funding, time and organization to iteratively improve games through alpha and beta testing in classrooms. This took a team of 10 people a minimum of one and a half months to create a short eBook with one game. In the next two years, the IMapBook researchers embraced a lower labor model, using an in-house authoring system to create simple game-like interactions such as conversations with characters, where players, in response to questions from avatars, clicked on word-buttons to make responses. See Fig. 3.1.

With this system, a team of three-four researchers, in one week, could create one such short eBook with one game and one small-group discussion. While one eBook a week is an improvement over one game a month, it was not fast enough for a mass market.

A look at the steps in the process reveal new bottle-necks. Researchers/designers: (1) read the text for the eBook finding key points in the narrative or in the content to place a game, (2) brainstorm game ideas, (3) select one idea and flesh out a game script, specifically questions and answers to those questions and foils (incorrect answers), (4) refine the script, (5) input the script into the authoring system, (6) test and refine the game, and (7) add avatar images for character expressions, neutral, happy and sad.

The current authors hypothesize that NLP and other forms of AI can automate steps one through five. Such automation would allow IMapBook to enter the mass market. It also would have huge implications for educational games in general. Since much of educational knowledge is represented in text, such text to games automation could similarly move educational games to a mass market position, where educational games could be quickly custom generated. The next case study illustrates another such similar need.

3.1.2 Gamifying a University-level Course

The second use case is related to gamifying a university-level course, i.e. modifying and tailoring the existing course materials to fit the paradigm of gamification and the platform of choice that is implemented to support and ease the use of gamification concepts in educational practice.

The platform of choice (Classcraft[1]) features many techniques of gamification, including but not limited to avatar creation, special powers, experience points and levelling, achievements, task-oriented progress, mechanisms of boosting positive and discouraging negative behaviour, and many others. As opposed to standard class materials, a unit of content in Classcraft is formatted as a task, consisting of an optional story and an optional assignment (at least one of those must be specified). Several tasks can be found in a single quest, which has, in addition to the tasks, a beginning and an ending node that consists of a story only.

The standard course materials are divided into parts, each of which is usually delivered in one week of the semester. These parts are naturally translated to quests in the gamified setting of choice, while assignments usually performed during classes can be modelled as tasks.

The greatest challenge that emerges when standard course materials are *translated* into the gamified environment is related to the effort of creating a story that can be used to create a setting for the used elements of gamification, and that can be set in the chosen imaginary world, while containing the concepts semantically related to the contents of the applicable course materials. Generating such a story is important, as it helps immersing students in the gamified world, and delivering them the fundamental ideas of the course material in a context that is removed from the rigid constraints of the real world, i.e. the story can easily feature e.g. situations where the core concepts of the course material are applied. In other words, a concept such as *intelligent planning* might be described through a story not strictly by formalised expressions, but for example, as a set of movements and actions that a seer gives to a blind knight who is saving a dragon's prisoner.

Generating such stories is a time-consuming process. With a system that can generate basic plot points in a world of a chosen context could speed up the process. Furthermore, the authors hypothesize that having a system that can automatically generate outlines of a story based on the given textual input content (the course materials) could make it easier to generate stories and narrative course-related content, and thus ease the process of students understanding the content. Ultimately, it would be helpful to have additional serious games (e.g. simple assignments or quizzes) be generated automatically based on the provided course materials and their textual content, that would be integrated into the gamified world and that might be used for revision and self-assessment.

The rest of the chapter is organised as follows. The following section contains a brief overview of the published research related to the topic of this chapter. Section 3.3 describes the proposed approach on a conceptual level, followed by Sec. 3.4 presenting an example of what the final product of the system using the proposed approach could look like. Finally, Sec. 3.5 features the concluding remarks.

3.2 Related Work

As a specific problem in the broader context of automated programming, and by extension software engineering [16], automated design of computer games is a problem that has been researched since at least the beginning of the millennium [83]. The Extensible Graphical Game Generator (EGGG) contained some prior knowledge about the domain of the game described in a language that is

[1] For further information, visit: `https://www.classcraft.com`

similar to that used by the modern-day interactive fiction tools, such as Inform 7 [78]. A textual description of a game, as presented by Orwant [83], is transformed into a graphical Perl program that is easily editable. Thus, with minimal effort put into customising the generated content, a number of games were generated, including: chess, poker, rock-paper-scissors, to name a few.

Nelson and Mateas [79] propose an approach to formalising mechanics used by the games that are to be generated, use them to generate games and employ the assistance of WordNet and ConceptNet to perform some basic reasoning in the process. Furthermore, the authors consider generating games to be a problem-solving activity.

The modern approach to automated game design and automated computer game generation is enhanced with popular AI methods, such as the approach of Guzdial and Riedl [35] where machine learning that generates new games based on approximate representations of existing games, and the recombination of the knowledge contained in those representations via conceptual expansion; the approach of Sarkar and Cooper [94], who argue in favour of the concept of creative ML – a set of ML approaches that are popular in the domains related to various forms of the arts, but somewhat neglected in the domain of video games; or the approach of Cook [16] and Cook, Colton, and Gow [17] that utilises co-operative co-evolutionary systems to automate game design of Metroidvania and arcade games.

Ultimately, methods of AI are used in various ways for specific game-development-related tasks [123], such as game balancing [86], level and content design [48, 63], or player modelling, etc.

Using the concept of analog and video games in the context of education is not a novel idea, yet the formal inclusion of gamification as the idea of featuring game-specific concepts in a non-game environment of higher education is still growing, and could be considered to be in its infancy [34]. Gamification combined with traditional teaching methods, such as classic lectures and reading, can improve learning effectiveness in almost every educational field, especially in science, technology, engineering, and mathematics (STEM) education [56].

In the context of education, Dicheva et al. [25] identified use of gamification elements such as badges, leaderboards, points, levels, progress bars, virtual currency and avatars, of which the most popular are badges, leaderboards and points. Badges should be awarded as individual awards for activities that require independent work by students. [50] explained that badges in gamification can be given to students for achieving certain skill or level of knowledge and that badges should be displayed in students achievement for social recognition and to engage motivation. Freedom to fail, current feedback, evidence of progression and storytelling are some of the essential elements of gamification that could be used in education [90]. Freedom to fail, a concept of formative assessment, occurs as one of the choices users can choose on their path of the game. Frequent feedback, as already necessary in traditional education, is a critical element for a player to know how they performed in game. Evidence of progression is seen in the form of levels or tasks and storytelling puts learning in a realistic or a fantasy context. Furthermore, storytelling and coherent narrative can be observed as engagement mechanisms in educational games [6, 43, 66].

According to Huang and Soman [41], gamification in higher education lets students approach new knowledge and skills through fun environment, and minimises negative emotions and lack of motivation that students encounter in traditional forms of education. Also, gamification in education can be a powerful tool for achieving learning objectives when implemented properly.

The approach to be used in including gamification in education, especially higher education, and achieving success is still a problem to be solved [2, 7, 76, 114, 117]. The recently increased popularity and use of eLearning systems opened new opportunities and a stronger foothold for gamification in higher education [58, 122]. Using the elements of gamification does not necessarily lead to an environment some might classify or perceive as childish, as serious games represent a valid choice [3].

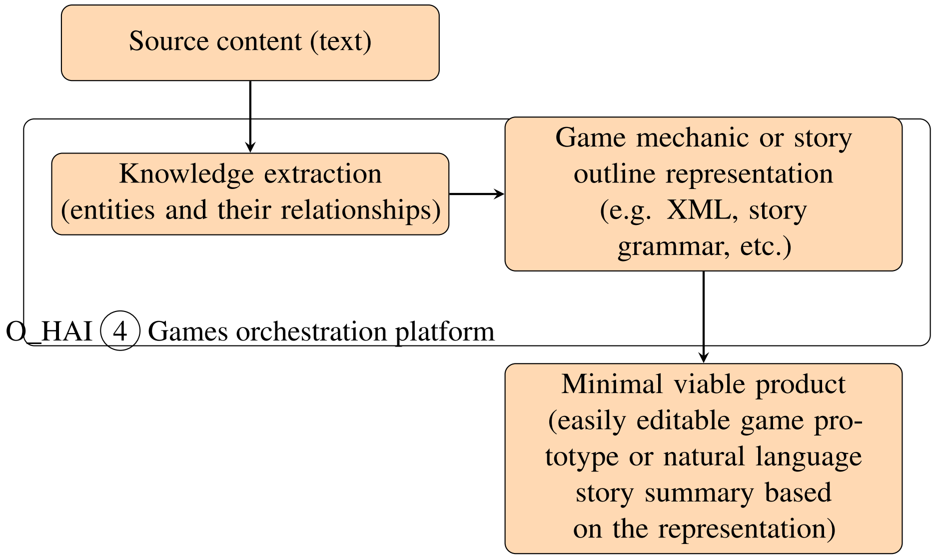

Figure 3.2: Conceptual model of the proposed approach

The system proposed in this chapter is to be used for automatically designing a video game that is educational or that can be used in educational purposes. One of the first tasks that the authors want to tackle is automatically generating meaningful questions based on the text input given to the system. Automatically generating questions is an application domain of NLP that uses various algorithms of NLP and methodologies to generate questions from a given text input [49, 85, 91]. Higher education, and education in general, is a welcome application domain for automatically generating questions [8, 38].

The approach that the system described in this chapter intends to use is based on semantic analysis of the input text and recognition of key entities and their relationship – an approach that is already somewhat established in the context of automated question generation in higher education [26, 62, 70]. Further work and development would allow the system to automatically develop simple educational video games, as described farther in this chapter.

3.3 Conceptual Model

Automated generation of simple educational games from large swaths of knowledge content is closer than it seems, in fact eminently doable. See Fig. 3.2 for a general conceptual model detailed in this section. From the long-lost library of Alexandria, to monks hand copying volumes in medieval churches, to Gutenberg's press, to eBooks, to web-pages; most of human knowledge, past, present and future, is contained in text.

It takes three neat technical tricks to transfer key, core, concepts to learning games. First, we abstract knowledge from books, using NLP to extract entities and their relationships from texts. This step can be implemented using services that can use, but are not limited to, NLP algorithms or methods, such as the one described in [87]. Second, we map those key entities and their relationships to a simple computer language that represents a few game mechanics. Third, an interpreter provides the game-play experience to learners. The former is planned to be supported by an extensible set of predefined game mechanics providing support for various games that follow a common implementation template. The second step might be further adapted if some of the state-of-the-art methods are utilised, such as GPT-3 [13] or similar. Figure 3.2 shows the basic conceptual scheme.

The most complex and challenging part in the described process illustrated in Fig. 3.2 is converting the recognised and extracted entities contained in the source text, and their relationships, into a simplified syntax that is adapted to be used as an input in the process of generating a minimal viable product, i.e. a game-play experience for learners, or at very least an easily editable game prototype based on the simplified syntax. The ultimate goal of the system described herein is to generate a real-time game that is based on a source textual content, and is applicable to learning environments. Although this translation itself is not necessarily extremely complicated, the prerequisites of it might be.

Although implementing the above described process sounds daunting, even in the light of recently published research on automated game design and automated game generation (discussed in Sec. 3.2), breaking it down to smaller problems that can be tackled one at a time renders it as a highly solvable problem, especially when the research and development are carried out for specific application domains first, and a general model is built based on the performance of those more specific. Furthermore, the research of this chapter is constrained to specific types of games with a specific purpose, as opposed to proposing a general approach that aims at being able to automatically generate any type of a video game. The complex structure of such a complex process can be broken down to services that can be considered microservices [60] in the context of implementation. Such microservices should be fine-tuned and efficiently organised.

Organisation of microservices, and distributed microservice-based systems is the main goal of the orchestration platform [98] that is being developed as the integral part of O_HAI (4) Games project, thus rendering it as a perfect foundation and companion for building the system described in Fig. 3.2. This platform is being developed as a specialised platform for orchestrating microservices that feature and use various methods of HAI, which is a welcome feature for the approach presented in this chapter.

The first step towards the mentioned ultimate goal is modelling and developing a system that can generate real-time games for the IMapBook platform. Such games use a simple description based on Extensible Markup Language (XML). Their structure and implementation are presented below, in Sec. 3.4.

Although the example of an IMapBook game described in Sec. 3.4 is extremely simple, the initial goal of the proposed system is to be used to automatically generate serious or education-oriented games based on predefined templates, such as various kinds of games utilising the platformer-genre-specific game mechanics (e.g. connect-four, or bubble shooters, or classify-the-elements, etc.), or boardgame-style multiplayer video games that would enrich the educational aspects of playing a game with social elements, thus enhancing the experience and the process of learning through interaction, socialisation, and healthy competition.

3.4 IMapBook Game Example

Two parts, (1) A simple computer language that represents a few game mechanics, and (2) an interpreter provides the game-play experience to learners, exist in IMapBooks. In IMapBooks, eBooks and their games are represented with a simple XML.

For instance, the simple conversation with character game where players click on buttons with words to answer a character's questions (pictured in Fig. 3.1) is represented by this code (a simplified excerpt of the actual XML) for a page in the eBook. The first line of XML code below defines an eBook page of type 2, meaning a text game page, which includes lexicon buttons, graphics and text messaging with feedback (see Fig. 1). Other page types include text pages, graphics only games and text games with no graphics. This type of game was developed to exercise students' inferences, a key part of reading comprehension.

```
<page type_id="2" chapter_number="" hidden="n" timeout="0" timer_last="1"
   ↪ timer_next="1">
```

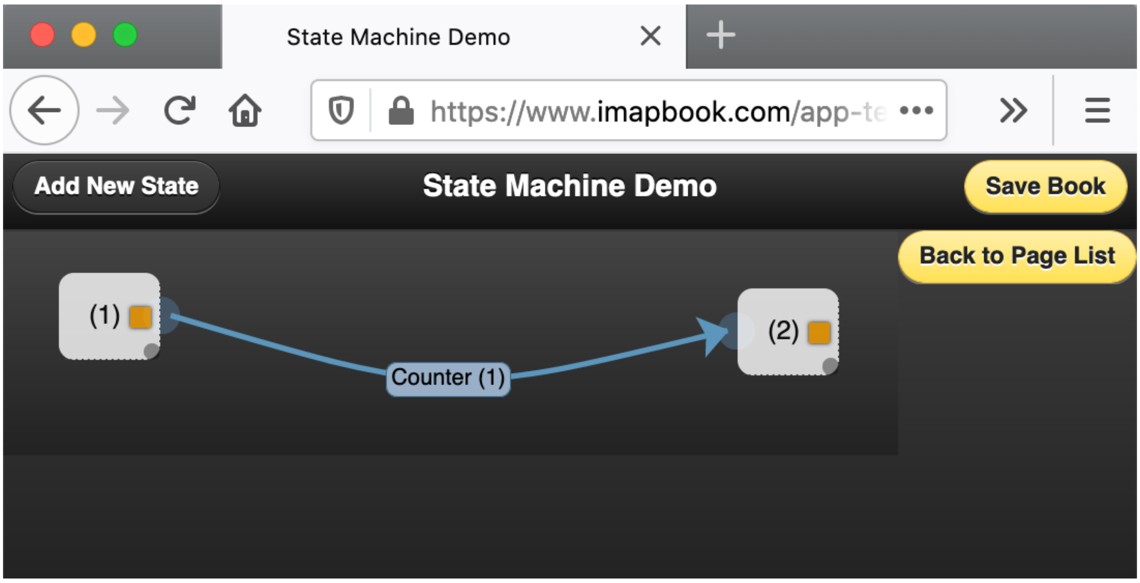

Figure 3.3: Screenshot of the state machine conversation with a character game in IMapBook

This next section of code defines the first part of a state machine used for simple text game interaction, with a lexicon of word buttons, two states and a transition. The player gets some initial game directions from the character, "What are the four questions I am wrestling with? Please put only one question at a time into the text area, then click on the check mark to submit." The player clicks on a sequence of words, on the buttons (Do, hate, know, him?, I, trust and love) to create a response and then clicks the check mark.

```
<state sound="" xloc="8.981481481481483" yloc="21.578514993281487"
    ↪ label="" url="">
    <text>
        <![CDATA[What are the four questions I am wrestling
            ↪ with? Please put only one question at a time
            ↪ into the text area, then click on the check
            ↪ mark to submit.]]>
    </text>
    <image file_name="LotT-arena.png"></image>
    <lexicon label="" text="" error="Please try again.">
        <word type_id="2" sound="" icon="" word="live without
            ↪ "></word>
        <word type_id="2" sound="" icon="" word="Do"></word>
        <word type_id="2" sound="" icon="" word="hate"></word>
            ↪
        <word type_id="2" sound="" icon="" word="know"></word>
            ↪
        <word type_id="1" sound="" icon="" word="him?"></word>
            ↪
        <word type_id="1" sound="" icon="" word="I"></word>
        <word type_id="2" sound="" icon="" word="trust"></
            ↪ word>
        <word type_id="2" sound="" icon="" word="love"></word>
            ↪
```

```
        </lexicon>
```

The next section of code shows counter transition (type=1), which requires four correct inputs (trigger=4) to go to the next state (state 1, defined by the following code section).

After the player clicks on word buttons and clicks the check mark, the IMapBook eReader interpreter attempts to match the text input with the "responses" coded into the transition below. If there is a match (for instance, "Do I hate him?"), it outputs the `text_output` to the player ("No way. I know that I don't hate him."). If the response is an incorrect response (type 2), then the character's avatar changes (avatar = "3"). Note that the next `text_output`, "Do I trust him?" is a correct input, receives a response of "Absolutely. This is the question that burns inside of me." and the character's avatar changes (avatar=2). Note that this code is simplified for clarity, so there are only two inputs, even though four correct inputs are required to make the state machine move to the next state.

```
        <transition type_id="1" variable_idx="-1" trigger="4"
           ↪ next_state_idx="1" label="" scenario_id="0">
            <response type_id="2" sound="" weight="0" bits="0"
               ↪ asub="n">
                <text_input character="0" avatar="0">Do I hate
                   ↪  him?</text_input>
                <text_output character="4" avatar="3">No way.
                   ↪ I know that I don't hate him.</
                   ↪ text_output>
            </response>
            <response type_id="1" sound="" weight="0" bits="0"
               ↪ asub="n">
                <text_input character="0" avatar="0">Do I
                   ↪ trust him?</text_input>
                <text_output character="4" avatar="2">
                   ↪ Absolutely. This is the question that
                   ↪ burns inside of me.</text_output>
            </response>
        </transition>
    </state>
```

The next section of code shows the next and last state of the game and page. Note that each game requires one blank state, such as this at the end of the game. A game can include as many states and transitions as the designer desires.

```
    <state sound="" xloc="69.83532934131736" yloc="22.37442922374429"
       ↪ label="" url="">
        <text>
            <![CDATA[You did really well. Select > to read on]]>
        </text>
        <image file_name="LotT-State-happy.png"></image>
    </state>
</page>
```

As mentioned, this conversation with character game, with simple avatar images that change expressions, uses a state and transition model, where transitions from one state to another are made based on "triggers." For instance, in the first state, a transition can be made by by making four correct inferences (those that start with response type_id="1"). There are a variety of other transition types, for instance time out transitions. There are other types of games represented with this simple XML language, for instance drag and drop games and hot spot games which can use simple animations. All of these games can include sounds, as well as speech to text synthesis as inputs and text to speech synthesis for output.

The web-based eReader is an interpreter for these games. Students read along in text pages until them come to a game page and then play the game. This simple XML language to represent games, and the eReader game interpreter are a proof of concept. It is much easier to generate this XML language that represents the game, in intermediary form, than to generate the more complex needed for game systems, such as Unity, Construct 3, etc.

The simple XML language that represents games and the web-based eBook system that interprets the games, can gradually be expanded to include a greater variety of games.

3.4.1 Use case two, proposed approach

Use case two requires a slightly different approach. Similar to case one, it takes the text content from an online/hybrid course, and generates entities and relationships. However, instead of generating a simplified description of a game mechanic (XML), it would generate an outline for the plot of a story, using story grammar [67].

Story grammar is the idea that stories within a cultural tradition follow very similar patterns. In western story-telling, the grammar typically follows these steps: (1) setting the stage: initial situation, including introduction to the setting and main characters, (2) conflict between characters or within a character (internal conflict) or between the character and the setting (man against nature), (3) protagonist (or his/her agents) attempts to resolve the conflict, or attempts to achieve sub-goals in resolving the conflict, (4) climax and (5) resolution of the conflict.

For case two, the story grammar plot would use the course content entities and their relationships, but also need to draw from a library of possible narrative themes (e.g., common fantasy, science fiction or adventure themes) and be framed in a way that lends itself to gamification of a course, e.g., attempts to resolve the conflict would need to be casts as tasks by the protagonist's agents. Also, perhaps some of the content in the course would need to be personified.

The final step for case two would be using the story outline as input to an NLP algorithm or an advanced neural network model such as GPT-3 to generate a natural language story summary that would be used as an introduction to the gamified course.

3.5 Conclusion

This architecture provides a way to automatically generate an arbitrarily large amount of games to support learning in any number of texts, including expository or fiction text. Once the basic architecture is created and run as a proof-of-concept, the system can gradually be expanded to include a wider range of games. This provides a means to create a vast repository of knowledge in an interactive, game form. If interactive game representations of knowledge elucidate other important aspects of knowledge, different from text, diagrams and video, perhaps the automatic generation of educational games from text could expand knowledge exponentially in ways reminiscent of the Gutenberg printing press.

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