Siren: Towards Adaptive Serious Games for Teaching Conflict Resolution

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Abstract: This short paper describes the Siren project, an interdisciplinary European project aimed at creating an adaptive serious game for teaching conflict resolution, and solve the research issues associated with this. We outline the challenges faced in various disciplines, including cross-cultural psychology, player modelling and procedural content generation, and the technologies and methods we will build on in order to solve these issues. We also discuss the design of the game and the means for validating our success. Though the project is just about to start, we have secured sizable funding, and conducted a few pilot studies on key component technologies.

Keywords: serious games, procedural content generation, player modelling, interactive narrative, cross-cultural studies, natural interaction

1. Introduction

Conflict arises in almost every stage and context of human life, from the schoolyard, to the workplace, and certainly in the arena of politics. Changing patterns of population migration have further complicated matters, as in culturally heterogeneous societies, people can no longer assume shared implicit cultural rule sets guiding acceptable modes of behaviour, let alone conflict resolution (Ting-Toomey and Oetzel, 2001; Weaver, 2000). There is widespread agreement that the current prevalence and lack of resolution to conflicts is incurring substantial cost to society at large. Efforts have been made to integrate the teaching of conflict resolution mechanisms into mainstream education, yet clearly many of these attempts have enjoyed limited success.

Technology, serious games, and simulations have already proven viable and effective for supporting therapy (DiFede and Hoffman, 2002), promoting intercultural communication (Raybourn, 1997), increasing understanding of ethnic, religious and historical funded conflicts (Buch and Egenfeldt-Nielsen, 2006), and representing different perspectives on issues such as global politics and foreign policy (Frasca, 2003). To the best of the knowledge of the authors, however, no existing applications or projects have focused on applying adaptive intelligence techniques for supporting conflict resolution.

This is the overall goal of a long-term project that the authors are undertaking: to develop a multiplayer, collaborative serious game using adaptive intelligence that focuses on educating young people about socially and culturally suitable methods of conflict resolution. As conflict is often highly contextually dependent and rooted in issues surrounding resources and player dynamics, adaptive approaches seem particularly well suited towards the task of generating conflict scenarios. For the purpose of learning, the game scenarios will need to be tailored towards players, play styles, and intended learning outcomes.

In the following, we will outline the system architecture of our conflict resolution game (CRG), and focus on how we will generate adaptive conflict scenarios.

First, we will describe our current ideas for the design of the game itself. We will then discuss the development of computational cognitive, affective, and cultural models of players, based on metrics of players' playing styles and other indications of cultural disposition, affective state and cognitive processes. As our CRG is multiplayer, we have also decided to incorporate group modelling. To this end, we will describe how we intend to use clustering and co-evolution algorithms for identifying patterns of group dynamics and emergences in collective play styles.

Next, we will discuss the role of the game conflict generator. The generator which will be supplied with intended learning outcomes for players, alongside libraries containing components relating to the desired conflict "domain", e.g. resources, desires, social limitations, and so on. Using this information along with the player and group model information, we will discuss how we will use global optimization algorithms to configure conflict scenarios optimized for the abilities of players.

While the basic algorithms that will underlie the adaptive game conflict generator have been demonstrated in other contexts (Togelius and Schmidhuber, 2008; Yannakakis and Hallam, 2009; Pedersen, Togelius and Yannakakis, 2010) they have not been combined before and applied to this domain. Potential challenges we foresee include managing the computational effort of scenario simulation and the uncertainty in predictions of scenario outcomes and difficulty.

Those parts of the project we describe here all somehow relate to computational intelligence; the consortium is interdisciplinary and includes other members focusing on natural interaction, multimodal affective analysis and game engine implementation, among other topics.

2. What is a conflict resolution game?

We propose a new type of game, the 'conflict resolution game' (CRG) which can only be played together with others and which can only be won as a group. The main purpose of a CRG is to teach players peaceful and constructive ways for resolving conflicts, knowledge that can then be transferred to other domains. The players (who can be divided into one or several groups or "sides") will face a conflict situation together. The conflict will be implemented as a scenario whose domain will be appropriate to the interests, maturity, and level of general knowledge of the participants. Examples of domains could be a classroom, an after-school sporting event or a home environment. Each scenario will contain one or more goals, which players need to achieve, a number of obstacles, and means to overcoming the obstacles. In terms of game mechanics, these kinds of scenarios can be formalised as collaborative puzzle solving with constraints, where each participant has incomplete information about the overall state of the game; puzzle task paradigms have been successfully used in the context of collaboration (Kraut, Gergle, Fussell, 2002). All of these elements will support the learning objectives of the game by immersing players in the conflict, facilitating a critical approach to their assumptions about the conflict and allowing them to explore new perspectives other than their own. We give demonstrative examples in two domains:

- In a classroom scenario, a group of students jointly work on a math problem for a graded assignment. All members of the group are aiming for the highest grade (goal). One of the students suffers from a learning disability and is unable to contribute equally (obstacle).
- In a home scenario, four family members have to share household tasks amongst themselves such that everyone feels the tasks have been distributed fairly (goal). Family members' varying perceptions of the difficulty and value associated with carrying out each task need to be overcome (obstacle).

Central to our research effort is that the games will be automatically adapted to suit the target players, both in terms of their skills, cognitive patterns and preferences. This requires advances in player modelling, both of individual players and of groups of players. As the game will be used in schools around Europe, and inter-ethnic conflict is one of the types of conflicts it models, cultural factors will also have to be taken into account in the adaptation mechanism and scenario generation.

3. Affective player modelling

One of the core concepts of our work is the generation of taxonomies of in-game affective user states, related to computational models of affect, emotions and context. Various definitions of the role and nature of affect and emotions are provided by different scientific approaches. For the more general definition, one crucial aspect is the distinctive features of emotions as compared with other psychological states – also having an affective element in them. In our CRG, we will incorporate Scherer's proposal (Scherer, 1987) for distinguishing the following classes of affective states:

- Emotions (e.g., angry, sad, joyful, fearful, ashamed, proud, elated, desperate)
- Moods (e.g., cheerful, gloomy, irritable, listless, depressed, buoyant)
- Interpersonal stances (e.g., distant, cold, warm, supportive, contemptuous)
- Preferences/ Attitudes (e.g., liking, loving, hating, valuing, desiring)
- Affect dispositions (e.g., nervous, anxious, reckless, morose, hostile)

Theories that focus solely on the recognition and classification of the consequences/ symptoms of an affective episode (such as facial expression, gestures etc) lead to shallow models (Sloman, 2001), as opposed to theories that focus on the affect, or emotion, elicitation process. The most common shallow models are those based on categories and those based on dimensions. Their role is paramount since they provide the representation tools required for bridging the gap between low level features/signals and higher level modelling of cognitive processes. In brief, categorical representations are the simplest and most wide-spread term used to describe an emotional state.

According to another classification of affect computational models by Hudlicka (2003), based on the level of abstraction, the end points of this spectrum are represented by models of individual circuits, or simple psychological phenomena on the one hand, and entire architectures integrating affective processing on the other. At the higher level of abstraction are architecture-level models which embody emotional processing. At an intermediate level of abstraction are task-level models of emotion, which focus on addressing a single task, such as natural language understanding or specific problem solving. At lower levels of abstraction are mechanism-level models, which attempt to emulate some specific aspect of affective processing. The models in this category attempt to emulate some aspects of the mechanisms involved in emotional processing, and are therefore at the process-level end of the modelling approach spectrum. They include symbolic, connectionist, and hybrid connectionist-symbolic approaches. Hudlicka divides these models into those addressing higher-level phenomena, such as mood congruent recall, the effect of emotion on performance, and the cognitive appraisal process itself, and lower-level phenomena, such as classical conditioning, connectionist models of the interaction of cognition and affect and multiple processing systems (e.g., implicit and explicit processing), and network models of psychopathology. The latter tend to be implemented using connectionist architectures.

The design features proposed for the differential definition of these states are partly based on a) response characteristics, such as intensity and duration or the degree of synchronization of different reaction modalities (e.g., physiological responses, motor expression, and action tendencies); b) antecedents (e.g., whether they are elicited by a particular event on the basis of cognitive appraisal); c) consequences in terms of stability & impact on behaviour choices.

The first step in being able to adapt the game to the players is to acquire reliable models of relevant aspects of the players. As our models will be data-driven, we first need to define of relevant metrics of playing style and other indications of affective state and cognitive processes, as they can be gathered from user interaction with the system. Experimental protocols will also be designed to elicit self-reported affective state and cognitive focus, e.g. via forced-choice questionnaires.

Next, modelling techniques from computational intelligence will be employed to model the dependency between user states and interaction. A prime candidate here is neuro-evolutionary preference modelling, which has previously shown good premise on similar tasks. Sequence and association mining will be used to investigate temporal dependency between user states, and sequence learning techniques like Long Short-Term Memory (Hochreiter and Schmidhuber, 2007) or recurrent neural networks (Caridakis, Karpouzis, Wallace, Kessous, and Amir, 2010) to predict user states from sequences of previous interactions. Care will be taken to follow good experimental methodology in all steps (data collection, proper experimental methodology, computational intelligence for user modelling/profiling, game parameterization, evaluation of models), including measures to validate the consistency of self-reported emotions and avoid spurious associations.

4. Group modelling

The Siren game is not meant to be played alone, but in cooperation with a group of other players. Therefore we need to extend our modelling efforts to modelling groups of players, including their internal dynamics. The literature on this topic is very limited; the few examples include (Yannakakis, Lund and Hallam; Karpouzis and Maglogiannis, 2009) – data driven player group type and player group dynamics identification is largely unexplored territory - so we will have to invent the methods, by following closely insight from social theories.

Our main approach will be to use unsupervised learning methods, such as clustering and self-organizing maps, to identify player types based on game play metrics. In a first step, extensive data about all aspects of game play will be logged from play-throughs of example scenarios. Feature subset selection will then be used so as to find relevant feature sets that allow the prediction of player types that agree with those that can be found in existing research on player types for similar scenarios and players on whose playing style we have prior information. These features will then be used to find emergent player types in unknown scenarios and for unknown player populations.

For identifying group dynamics, a number of algorithms (Karpouzis and Maglogiannis, 2009) will be investigated. Initially, the system will be augmented with hierarchical clustering mechanisms that can find supersets of related playing styles. Clustering will also be used identify common patterns of individual playing styles arising in combination with and reaction to each other. A further, complementary approach to be investigated is to use co-evolutionary simulations of group dynamics (as commonly used in artificial life and in computational finance) to simulate the likely dynamics resulting from particular combinations of player types. The results of such simulation can be used to directly inform the game adaptation mechanisms, and also as part of a reinforcement learning mechanism to update the initial assessment of player and group types after a scenario has been played to its conclusion.

5. The cross-cultural perspective

A defining feature of our CRGs is the consideration of culture as an important component affecting and informing conflict resolution technique: while people of some cultures gravitate towards more confrontational methods of resolution, others tend to avoid them. Accordingly, as well as tracking players' individual-level affective states, at the start of each play session, players will select a dominant cultural orientation. Relying on the empirically validated research led by Schwartz (2006) on cultural value profiles, each player will be assigned a "default" initial cultural persona. The initial cultural personas will then be compared to those of all other players involved, and also analysed against the specific game scenario, to identify potential points of tension for each player. Based on the predicted tension point analyses, the scenarios will be adapted according to the specific objectives of the game scenario and the learning teachers have in mind for their students. For example, for the purpose of learning, teachers may want to elicit more confrontational behaviours from students who might typically be expected to adopt conflict-avoidance techniques. These individual cultural personas will only serve as a starting point, however. As play progresses, they will be adapted based on actions adopted by players. In this way, potential poor classifications in terms of cultural orientation are eventually self-corrected.

6. Adaptive game conflict generation

In most computer games, the scenarios, levels, narratives etc. are almost completely scripted in advance. Creating all this game content is a major effort and consumes a large part of the development budget for a modern computer games. For this reason, a number of commercial games use some form of procedural content representation where algorithms are used to create complete environments from compact initial descriptions or random number generator seeds. Most of the successful attempts are limited to environments of some kind. Levels and maps in a few strategy games (e.g. the *Civilization* series) and landscape elements in many shooter games (e.g. *Far Cry II*) are typical examples of procedural content generation. As far as we aware, procedural content generation based on player models does not exist in any commercial game yet.

In the Siren project, we don't have the luxury of having professional game designers create a multitude of scenarios for all possible combinations of players and groups of players. Instead, we are pursuing a considerably more ambitious goal: developing mechanisms for automatically creating and adapting conflict scenarios according to given conflict domain specifications and player models.

In order to operate, the game conflict generator will need to be given information about the conflict domain and a library of conflict components (resources, desires, taboos etc.), and a model of the skill and experience of the players involved; it will also be supplied with desired learning outcomes for the participants. It will then use global optimization algorithms such as evolutionary computation and particle swarm optimization to configure a conflict scenario that would be optimized for the abilities of the player and if possible provide the desired learning outcomes. The optimization algorithm will evaluate each potential scenario and assign a fitness (or "goodness") to it based on a simulated play-through of the scenario, with AI players that play according to the model of the human players; we have already conducted some pilot studies on this (Togelius and Schmidhuber, 2008; Togelius, De Nardi and Lucas, 2007). The scenario that best provides the correct skill level and challenges that are likely to satisfy the desired learning outcomes is chosen for actual play, and the outcome of the play session is used to update the model, following our approach in (Yannakakis and Hallam, 2009), (Pedersen, Togelius and Yannakakis, 2010).

During game play, if the outcome of the game differs strongly from the outcome envisioned by the simulation, in such a way that the learning outcome might not be satisfied, the conflict generator will dynamically adapt the game during game play. This can be done e.g. by introducing new constraints or other factors to the conflict, or hints to guide the players. While the basic algorithms that will underlie the adaptive game conflict generator have been demonstrated in other contexts, they have not been combined before and applied to this domain. Challenges associated with achieving good results on this task include managing the computational effort of scenario simulation and the uncertainty in predictions of scenario outcomes and difficulty. A further challenge for application of basic evolutionary algorithms to this project involves translating scenario variables that indicate qualities like narrative coherence and dramatic impact, into an objective evaluation function for optimization. While techniques for declarative optimization have been applied to drama management in Façade, an addition of pedagogical goals to narrative goals will require further investigation.

7. Adaptive narrative generation

The scenarios generated by the game will need to be accompanied by believable and motivating narrative. Obviously, the narrative will need to be adaptively generated on the same conditions as the scenarios. There exists a sizable body of previous academic research on narrative generation, but it has rarely been applied to serious games, or built on player models. Narrative generation systems like Fabulist (Riedl and Young, 2006) and Gadin (Barber and Kudenko, 2006) rely on declarative representations of plot-structure and explicit reasoning about causal structure of stories. These approaches guarantee coherent, dramatic narratives but put the burden of authoring plan operators and domain descriptions, the representations of which are not accessible to authors. Reactive planners like ABL provide real-time dramatic reactions for drama management, but do not contain higher-level narrative representation and rich causal narrative structure. SIREN's approach will combine traditional planning with reactive approaches to cater for in-game events and player actions WideRuled and StoryCanvas (Skorupski, Jayapalan, Marquez and Mateas, 2007) are tools that provide an intuitive interface for authoring story domains. SIREN will incorporate and advance StoryCanvas to incorporate support for authoring story goals as well as pedagogical goals and reduce the authorial burden.

8. Validation

In collaboration with the pedagogical consultants of the project, user-experience evaluations will run in two schools located in Denmark and Greece. To ensure our results apply to the entire gamut of students, we will involve a diverse panel of individuals of all genders, of different cultural backgrounds when possible, and possessing variable expertise with computers. The aim of these studies will be to gain insight on the social-psychological aspects of game play on students and teachers.

- 1. At an individual 'micro' level, the game will be designed to educate children on matters of conflict resolution. Therefore, our first question will focus on whether children are able to resolve conflicts with others in more productive ways *after* having used the game.
- 2. The game will be designed to assist teachers with the challenging task of providing a social education to their students. Our second question regards whether teachers' communicative aptitude, and confidence in the resolution management lessons they impart to their students, improve when having the game to their disposal.

- 3. At a macro level, the game is designed to make a social impact. Our third and final question centers on whether the game (as a mechanism that resolves otherwise lingering conflicts) moderates students' overall shared social capital. In other words, compared to before interacting with the game, is students' perceived group cohesiveness higher?

Interviews and role-playing exercises will be used to answer the first and second research questions. Surveys, using established measures for social capital, will answer the third question.

9. Conclusion

We have outlined the approach we intend to follow in order to develop a new type of game, the conflict resolution game, intended to teach conflict resolution skills to (in the first instance) school students across Europe. We have also described the approaches to player modelling, group modelling, content generation, narrative generation we intend to take and the validation. At the moment the project is on a conceptual stage, but with a dedicated multidisciplinary team and recently awarded funding from the European Union we are confident we will move forward swiftly. Success of the project will mean a number of advances in educational games design and technology, including the first time computational intelligence techniques will be used as the basis for an educational game.

References

Barber, H. and Kudenko, D. (2008), Generation of Dilemma-based Narratives: Method and Turing Test Evaluation, *First Joint International Conference on Interactive Digital Storytelling (ICIDS)*, Springer LNCS 5334.

Buch, T. and Egenfeldt-Nielsen, S. (2006) The Learning Effects of Global Conflicts: Palestine. *Media@Terra Conference Proceedings*.

Caridakis, G., Karpouzis, K., Wallace, M., Kessous, L. and Amir N. (2010) Multimodal user's affective state analysis in naturalistic interaction. Journal on Multimodal User Interfaces, Springer, Volume 3, pp. 49-66.

DiFede, J. and Hoffman, H. (2002) Virtual Reality Exposure Therapy for World Trade Center Post-traumatic Stress Disorder: A Case Report. *Cyber Psychology & Behaviour*, 5(6), pp. 529 – 535.

Frasca, G. (2003) Ideological Videogames: Press left button to dissent; *International Games Developers Association*: Ivory Tower; November.

Hochreitern S. and Schmidhuber, J. (2007). Long short-term memory, *Neural Computation*, vol. 9, no. 8, pp. 1735-1780.

Hudlicka, E. (2003) To feel or not to feel: The role of affect in human-computer interaction. *Int. J. Hum.-Comput. Stud.*, 59, pp. 1-32.

Karpouzis, K. and Maglogiannis, I. (2009) Modeling and delivering heterogeneous audiovisual content for group consumption. *Signal, Image and Video Processing*, 10.1007/s11760-009-0107-6.

Kraut, R. E., Gergle, D., Fussell, S. R. (2002) The use of visual information in shared visual spaces: informing the development of virtual co-presence. In *Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work* (New Orleans, Louisiana, USA, November 16 - 20, 2002). CSCW '02. ACM, New York, NY, pp. 31-40.

Pedersen, C., Togelius, J. and Yannakakis G. N. (2010). Modeling Player Experience for Content Creation. *IEEE Transactions on Computational Intelligence and AI in Games*, vol. 2, issue 1, pp. 54-67.

Raybourn, E. (1997) Computer game design: New directions for intercultural simulation game designers. In *Developments in Business Simulation and Experiential* Exercises, 24.

Riedl, M. and Young, R. M. (2006) From Linear Story Generation to Branching Story Graphs, *IEEE Journal of Computer Graphics and Applications*, May/June, pp. 23- 31.

Scherer, K. R. (1987) Toward a dynamic theory of emotion: The component process model of affective states. *Geneva Studies in Emotion and Communication*, 1, 1–98.

Schwartz, S. (2006) A Theory of Cultural Value Orientations. In: *Comparative Sociology*, Volume 5, Numbers 2-3, pp. 137-182.

Skorupski, J., Jayapalan, L., Marquez, S. and Mateas, M. (2007) Wide Ruled: A Friendly Interface to Author-Goal Based Story Generation. *International Conference on Virtual Storytelling 2007 (ICVS-2007)*: pp. 26-37.

Sloman, A. (2001) Beyond shallow models of emotions. *Cognitive Processing*, 2(1):177—198.

Ting-Toomey, S. and Oetzel, J. (2001) *Managing Intercultural Conflict Effectively*. Thousand Oaks: CA.

Togelius, J. and Schmidhuber, J. (2008) An Experiment in Automatic Game Design. *Proceedings of the IEEE Symposium on Computational Intelligence and Games.*

Togelius, J., De Nardi, R., and Lucas S. M. (2007) Towards automatic personalised content creation for racing games. *Proceedings of IEEE Computational Intelligence and Games*.

Weaver, G. (ed.) (2000). *Culture, Communication and Conflict: Readings in Intercultural Relations*. Pearson Publishing: Boston.

Yannakakis, G. N. and Hallam J. (2009) Real-time Game Adaptation for Optimizing Player Satisfaction, *IEEE Transactions on Computational Intelligence and AI in Games*, vol. 1, issue 2, pp. 121-133.

Yannakakis, G. N., Lund, H. H. and Hallam, J. (2006) Modeling Children's Entertainment in the Playware Playground. In *Proceedings of the IEEE Symposium on Computational Intelligence and Games*, pp. 134–141, Reno, USA, May. IEEE