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Virtual General Game Playing Agent

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Abstract. We developed a virtual game playing agent with the goal of showing believable non-verbal behavior related to what is going on in the game. Combining the fields of virtual agents and general game playing allows our agent to play arbitrary board games with minimal adaptations for the representation of the game state in the virtual environment. Participants in preliminary user testing report the game to be more engaging and life-like with the virtual agent present.

1 Introduction and Motivation

Intelligent virtual agents, and more specifically embodied conversational agents capable of interacting with humans face-to-face, have served many roles, including as tutors, guides, trainers and actors. Providing more general companionship, such as social support to the elderly, is also gaining attention [15]. Being entertaining can help in that role, such as by being able to play various games. It is not just the game playing itself that delivers value in that case, electric games have been doing that for decades, but being socially present and responsive adds a completely new dimension [1]. Being able to play games can be a useful skill for companion agents, but picking up new games to play is not trivial.

General game playing (GGP) agents [9] have been developed with the goal in mind of defeating other agents at any game, as a sort of benchmark for effective AI strategies. Entertaining humans with an endless variety of game options has generally not been the focus of that research.

In this project, we combine a virtual agent and a GGP agent to create an intelligent virtual agent that approximates human strategies and reactions in order to create a believable opponent for human players rather than the best possible player. The use of a GGP engine ensures that the agent will never run out of games to play.

2 Related Work

Virtual and robotic agents, that express human-like social and emotional behavior while playing board games and card games have been built and studied.

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Some interesting results include strong human reaction to visual social behavior [14, 16, 3], the importance of also including negative feedback [1] and the importance of immersion [13]. Most of these systems implement a single game, such as chess [13, 16, 2], Skip-Bo [1], Reversi [7] and Risk [14]. A more general social game playing framework for virtual agents was proposed in [3], but the game specific logic does not follow a standard format. Our agent is the first virtual game playing agent that adopts a standard general game description language. Also, in order to possibly gain some of the benefits of immersive play space, our agent is presented within virtual reality.

A GGP agent is a game playing agent that is capable of playing an arbitrary game well, with no input other than the rules of the game. The GGP community uses the Game Description Language (GDL) [11] to describe the rules of games. Interpreting the GDL description of a game allows a general game player to simulate the game or search through the possible moves and future position to find a good move. While variants of Minimax search (e.g., [17]) used to be the standard approach, the difficulty of generating good heuristics for arbitrary games lead to the adoption of simulation-based approaches. Today the field is mostly dominated by Monte Carlo Tree Search [4, 9].

3 Approach and Implementation

In order to familiarize ourselves with the domain, we first collected data on how humans play a variety of board games against other humans. We had three people play both Checkers and Nine Men's Morris, 6 games in total. The games were recorded on video, their length ranging from 8 minutes to 30 minutes, and then analyzed for hand gestures, reactions and facial expressions.

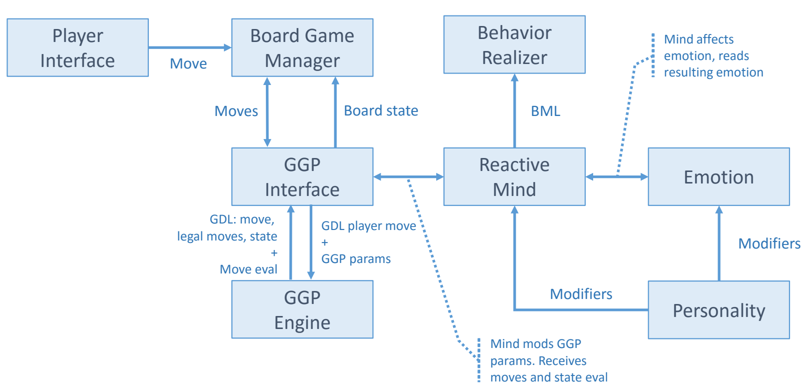

Fig. 1. Overview of the architecture. The GGP Engine is a separate process that communicates with the remaining Unity based system over sockets.

Our goal was to create an environment in Virtual Reality where you could meet a virtual human and play any game against it that could be represented in GDL. We accomplished this by coupling together a GGP engine and a reactive virtual agent framework in Unity 3D. An overview of the architecture is provided in Fig. 1. The focus is board games, where pieces can be placed, removed, captured and moved. A Board Game Manager handles these actions, as well as the mapping between the GDL and virtual board representation, while remaining agnostic to the actual game logic and rules. One can therefore quickly add new board games to the environment by providing the basic 3D assets and define GDL cell locations. While the architecture itself is not limited to board games, including other games such as card games requires new motion skills and changes to the environment configuration.

The virtual agent needs to display facial expressions, vocalize, gaze, and gesticulate with its hands, as well as move pieces on the board. We build on our own SAIBA architecture [12], using `FML` (Functional Mark-up Language) [5] to describe intent, and `BML` (Behavior Mark-up Language) [10] to describe its realization through behavior.

The GGP Engine runs on a simulation based search algorithm, specifically Monte Carlo tree search (MCTS) [4] that is built on top of ggp-base [18] – a Java framework that provides a skeleton for the messaging system and a reasoner for interpreting GDL to simulate the game. We extended the search algorithm in a few key ways: We added the MAST [8] and GRAVE [6] heuristics for faster convergence, discounting of values during back-propagation to decrease the value of far away victories we find, and horizon parameters that limit the depth of the play outs and the depth of the tree. To be able to affect the way the agent plays, we added the ability to pass parameters from the virtual agent to the GGP engine. There are more than 17 parameters of the search algorithm and our extension that can be affected, but most of those are nuanced and do not provide easily predictable changes. Some of them are very important for portraying a believable human player, such as how much the AI values keeping its own and removing opponent pieces, depth limit for the search and the chance of playing sub-optimal moves.

The role of the virtual agent is to visualize a particular opponent, both in terms of who the person is and in terms of how the game is dynamically unfolding. The implementation of the virtual agent is independent of what game is being played, as it only reacts to GGP abstractions (see Fig. 2). The state of the virtual agent can be broken into three aspects: Its *Personality*, as represented by the Big Five personality traits model (which happens to map relatively well onto GGP strategy); Its *Mood*, as represented by the valence and arousal model, similar to [1]; and one-shot *Emotions*, which are triggered by various conditions.

The agent has a mood which decays to a neutral state that is determined by its personality traits (a disagreeable agent would have a lower resting valence value). Personality traits can also modify readouts; an extroverted agent will have more exaggerated values on all axes. The mind of the agent evaluates and reacts to the move evaluation data it receives, which affects the mood and triggers

Fig. 2. Looking bashful in a game of Nine Men's Morris vs. thoughtful in Checkers.

one-shot emotions if the conditions are met. It receives move information and state evaluation data from the GGP interface, and evaluates how much it is in the agent's favor vs. the player's favor, and to what degree. The agent's actual behavior is generated via FML and BML. We extended FML and BML to support board game interactions and intent.

Each time the mind receives move and state data, appropriate FML is generated. Upon receiving a move, whether it is its own, or one made by the player, it creates a `ReactMoveFunction`, and if it is its own move, it will also create a `MakeMoveFunction`. It generates a `ConsiderMoveFunction` every few seconds upon receiving the cognitive data about the current state. Each of these are accompanied by an `EmotionFunction` which has the current mood stored, and are placed into a FML body which is then immediately interpreted. Transforming from FML to BML is where we see the effects of the agent state (one-shot emotions, the mood and the personality modifiers) on the visible behavior. Finally the behavior realizer schedules and executes BML chunks, such as moving pieces, changing poses, looking around. `EmotionFunction` gets mapped to an expression which is interpolated between four different expressions, representing the extremes of the arousal and valence axes.

4 Conclusion

The results from a pilot study with 13 participants, where each participants played against a visible and an invisible agent, agrees with previous research that has shown an improvement in subjective experience when game playing agents become embodied. It is encouraging to see how well people reacted to seeing the virtual agents despite dipping a bit into the uncanny valley (reported as "creepy"). It indicates that the idea of having a virtual agent to play against could enhance many such experiences even if it isn't perfect.

In conclusion, the contribution of our work is twofold: Using a formal game description to extend the capability of intelligent virtual agents, such as those in a companionship role, to play a greater variety of games with less effort; and to introduce modifications to GGP that start to address a more human-like style of playing, for the purpose of entertainment rather than competition.

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