Gameplay experience based on a gaze tracking system

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Introduction

Human-computer interaction is an important point in the development of software. In the field of games, it is a way to increase immersion in the virtual world for the player. Classical interactions with mouse, keyboard or gamepad, are limited in comparison with the reality of graphics displayed. Indeed, a big interest is to concentrate on new kinds of interfaces between the player and the virtual world. For example, some approaches are using a headpiece device to detect head movements in order to change the game camera direction. In this paper, we concentrate on using gaze direction as a new kind of gameplay. We intend to interact with narrative elements of the game without using any intrusive equipment for tracking. We present a prototype that has been developed in the framework of emergent narrative. We also describe how gaze tracking can be used in the framework of player behaviour detection for gameplay and adaptive narrative purpose. Indeed, we have developed a 3D adventure game in a virtual environment that represents our laboratory of computer science. An extension of this game will be to use methods that have been described above to allow the player to control the game by a gaze tracking approach. The other extension will be to use gaze detection to observe the player behaviour (for example stress, attention...) and adapt the game scenario dynamically.

An adaptive adventure game

Usually video games are based on linear narration which reduces significantly the field of interactions between the player and the environment he evolves in. In this case, we talk about linear games. The challenge is then to increase the player's freedom.

This is one of the reasons that explain why there is an increasing interest in narration in video games. Narration creates the drama and develops interest by creating challenges the player has to overcome. Narration should adapt the game unfolding in order to take into account the various levels of emotions (stress, frustration, rewards, etc.) needed to maintain the player's attention.

In this context, we have developed an adventure game based on the visit of a virtual world that represents the computer science laboratory (L3i) of the University of La Rochelle. The player has to explore the laboratory by opening doors that are closed. The figure 1 is a screen capture of the prototype that has been developed with the Unreal Engine editor.

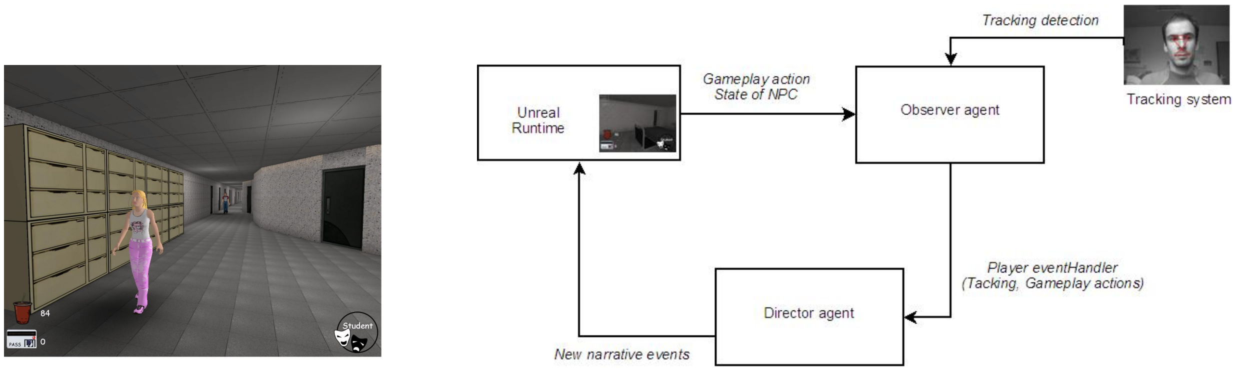

Figure 1. Left: A screen capture of the prototype. Right: Overview of a narrative based game architecture.

The game concept is the following one. The player is a student that has a fixed delay to give a work to his teacher. He is in direct competition with an *evil* student that tries to prevent the player from reaching his goal and with a *little pest* that tries to steal his work and give her own work first to the teacher. We propose to give to the player a maximum amount of interactivity while keeping a robust and interesting narrative framework. The approach of emergent narrative consists of a particular architecture that increases player actions freedom and produces a dynamic control of narrative quality. A challenge is, for example, to detect the player's behaviour in order to modify dynamically the scenario.

An interactive architecture

Game architecture

In (Champagnat, Prigent, & Estraillier, 2005) we have proposed an architecture for interactive storytelling. Like (Magerko & Laird, 2003; Young & Saretto, 2003), this architecture is made up of a process simulation and a story director (or planner). Figure 1 gives an overview of the architecture.

This architecture defines a set of agents that catches player's inputs, analyses the game unfolding and computes an adaptive execution of narrative (as a feedback to player's inputs).

The narrative controller proposes a consistent unfolding. According to the story director's analysis, it can enable or disable parts of the story. The narrative controller catches actions by means of an observation agent. This observer is being configured by the narrative agent (it gives a set of expected actions) at each execution step.

Let us give, in the sequel, a brief presentation of the agents that will interact with de gaze tracking system:

- *the observation agent* is in charge of capturing the player's behaviour. For example, the player chooses to open a door by clicking on it or by pressing the space bar key on its keyboard. The observation agent interprets this explicit action on controls (*i.e.* the procedures of the game) and translates it in a player action (in the sense of an action of the narration) corresponding to the player's choice. In our new gaze based interaction architecture, the observation agent also receives informations from the gaze tracking system (head pose, gaze direction, etc.).

- *the narrative agent* performs a supervisory control of the storytelling. It receives the players's actions from the observation agent, and determines the set of possible game events. It is also in charge with defining the parameters of the observation agent.

A low cost, robust gaze tracking system

The tracking algorithm we have developed is built upon three modules which interoperate together in order to provide a fast and robust eyes and face tracking system (see Figure 2).

- *The face detection module* is responsible for checking whether a face is present or not in front of the camera. In the case a face is present, it must also give a raw estimate of the face and face features (eyebrows, eyes, nostrils and mouth) 2D position in the image.
- *The face features localization module* finds the exact features position. When all features position are known, we use the method derived from (Kaminski & Shavit, 2006) to estimate the 3D position and orientation of the face. Gaze direction is processing by combining face orientation estimation and a raw estimate of eyeball orientation processed from the iris centre position in the eyes (Zhu & Yang, 2002).
- *The features position prediction module* processes the position of each feature for the next frame. This estimate is built using Kalman filtering on the 3D positions of each feature. The estimated 3D positions are then back projected to the 2D camera plane in order to predict the pixel positions of all the features. Then, these 2D positions are sent to the *face features localization module* to help it process the next frame.

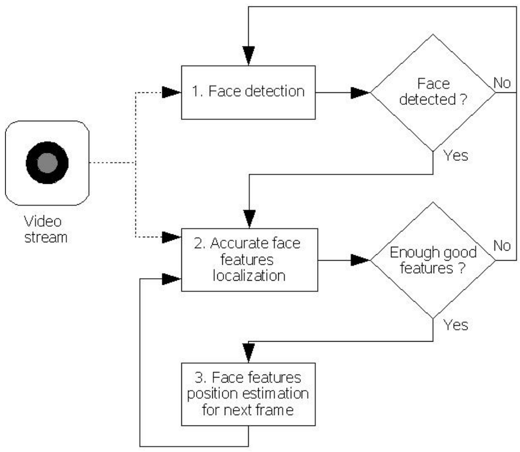

Figure 2. General architecture of the face and eye/gaze tracking algorithm.

During the system development, we focused on robustness. As a consequence, the system accuracy is lower than commercial systems like *Facelab*, but our solution is much less expensive and allows gaze tracking in a broader range of head poses.

Game / Gaze interaction

During our first experiments, we only took into account a few explicit player's behaviour:

- Firstly, we have focused on the interaction with the non player character of the *little pest*. She tries to steal the work of the player. The player can interact with the girl by doing a wink to the camera when he is in front of the girl. Then, the girl will give his work back to the player if she has stolen it to him.
- Secondly, we allow the player to protect himself against the *evil* student by looking down. Indeed, if the *evil student* arrives near the player, this one will put his head down and then the *evil* student will go on without stealing his work.

We have shown how gaze detection can be used for gameplay purpose. We now explain that implicit behaviour can be detected and how the game can dynamically adapt the scenario following these observations. We are currently working on the integration of more complex kinds of behaviour into our interactive game framework:

- First, we will use gaze tracking to observe the level of attention of the player. For example, if the player stops watching at the screen, a particular game action can be launched to refocus his attention.

  In L3i Life for example, in this kind of situation, the adaptive architecture can modify the unfolding of events, and make the evil student run after the player to steal his work. It is a stressing action that can bring some interest back to the player.

- Another possible observation is the stress of the player. There are a lot of possibilities for detecting stress. The scenario we have chosen to detect is the following one: the player keeps his head near the screen without any movement. We will interpret this behaviour as a big stress situation. During game level design, the main purpose is to guarantee a variation of stress during game execution. Using our stress observation method will allow to detect the moment when the player is stressed and give him some easy action to perform (no more enemies for a while) until the stress decreases.

Conclusion and perspectives

During our first experiments we have observed that this new kind of interaction improves the players immersion in the virtual world of the game. Moreover, it also increases its interest for the game because the gameplay is richer and the game more *fun* to play. These observations will certainly be confirmed once our framework will include the observation of implicit behaviour as we will have more real-time feedback on the user's gaming experience. In this paper, we have presented a system which reacts in a dynamic way thanks to the observation and analysis of the player's behaviour. We described the architecture of a general framework for game adaptation using gaze as one of its inputs. The principle of the interaction is based on the extraction of information according to the spatial and temporal context. The observation and the analysis of behaviour consists in determining the behaviour of players from their actions, by taking into account the scenario. It has proven to improve the gaming experience for adventure games. However, more behaviours are needed to improve and validate the proposed models and architecture.

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