Andromeda: A Personalised Crisis Management Training Toolkit

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Abstract. Over the last decades, technological advancements have enabled the gamification of many of modern society's processes. Crisis management training has benefited from the introduction of human-machine interfaces (HMIs) and wearable monitoring sensors. Crisis responders are nowadays able to attend training sessions through computer-simulated crisis scenarios while simultaneously receiving real-time feedback on their operational and cognitive performance. Such training sessions would require a considerable amount of resources if they were to be recreated in the real world. We introduce Andromeda, a toolkit designed to allow remote-access, real-time crisis management training personalisation through an applied game. Andromeda consists of a browser-based dashboard which enables real-time monitoring and adaptation of crisis management scenarios, and a remote server which securely stores, analyses and serves training data. In this paper, we discuss Andromeda's design concepts and propose future studies using this toolkit. Our main focal points are player stress response modelling and automated crisis management training adaptation.

Keywords: Crisis management · Game-based training · Serious games · Personalised games · Real-time adaptation · Player monitoring

1 Introduction

Traditional crisis management training is a paper-based, collaborative dynamic exercise [1]. In simple words, during training, a team of crisis responders are alerted and introduced to a simulated crisis scenario which they have to "solve" rapidly through efficient teamwork. Such training sessions are held frequently so that crisis responders are aware of all the possible threats and maintain a high level of preparedness [2].

However, certain weaknesses in the crisis training scheme have been identified [3]. First of all, often at times training sessions fail to induce high amounts of stress onto the trainees, as expected to happen in a real-life crisis situation. Ideally, crisis management training involves several highly stressful components (e.g.

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information under/overload, time pressure, peer/media/public pressure etc.). Even though such components are often included in the training scenarios, training sessions are focused towards trainee decision making, meaning that the effect of such stressors is given little attention. Moreover, mainly due to the training scheme's collaborative nature, trainees receive limited individual-level feedback on their performance. Trainee assessment is mostly done at team-level, which means that trainee performance is not measured individually, but with respect to the contribution to the overall team's performance.

This study aims to address the above two points; in order to shift the focus of crisis management training towards the individual trainee, we provide a personalised crisis management training environment through adjustable in-game components and just-in-time, individual-level feedback. Secondly, to study the effects of stress-inducing mechanisms during training sessions, we monitor individual trainee operational performance and stress responses through a real-time monitoring dashboard and wearable physiological sensors.

Our study is based on the dynamic game engine of the Mayor's game [4]. The Mayor's game engine enables the creation of crisis management training scenarios which can be adapted in real-time through adjustable in-game components. Over the last four years, the Mayor's Game has been widely used by crisis management experts in the Netherlands [5]. In the game, players act as the mayor of a fictional town undergoing a crisis. The crisis needs to be solved by answering a series of dilemmas for which, additional information is provided by non-player characters (NPCs) representing various institutions, such as the town's police or fire department. A screenshot of the Mayor's Game is shown in Fig. 1. Our study is aimed towards the training of the administrative crisis management team (off-site) and not the operational crisis management team (on-site), given that the Mayor's Game has been implemented to be played by administrative staff [4]. An example scenario of the Mayor's Game can be found in [6].

2 Related Work

Games have been used as a medium for crisis management training for decades. After World War II, military games were developed at Harvard University and Massachusetts Institute of technology to study the military and political dimensions of crisis management [2]. In more recent years, especially after '9–11', nation-wide crisis management simulations have been run in order to prepare both governmental and local safety agencies for terrorist threats [7]. As a natural consequence, researchers have been investigating ways in which crisis management exercises could be conducted through computer simulations. For an extensive review of crisis management training through serious games, we refer readers to Di Loreto et al. [8].

Walker et al. [9] discuss the usability and efficiency of virtual crisis management systems (CMSs). They describe crises as unique multi-variable entities, defined by location, affected population and relevant support organisations. These variables are continuously changing over time and are difficult to predict

Fig. 1. A screenshot of the Mayor's Game. The main game screen consists of five advisors (top half) which the player can consult in order to answer a series of dilemmas presented to them within a crisis scenario (bottom half).

in advance. Moreover, Walker et al. define four categories which can be fulfilled through crisis management games: *teaching, operations, training* and *experimentation*. Our study revolves around the latter two, *training* and *experimentation*; through Andromeda we aim to improve the performance of crisis mangement trainees by analysing their decision making processes under stressful conditions.

A notable example of a dynamic crisis management training application is Pandora [1]. Pandora provides a training environment for crisis responders, through monitoring of the emotional and behavioural state of the trainees [10]. The developers of Pandora define key "affective factors" which are used to model trainees' emotional state, namely *personality traits, leadership style, background experience, self-efficacy, stress* and *anxiety*. Similar to our study, Pandora recognises trainee stress level as an essential factor based on which, several in-game variables are adjusted in order to provide personalised crisis management training experiences. However, unlike Pandora, Andromeda enables fully remote crisis management training sessions, even when the trainer and/or trainee are not located in their typical working environment.

Physiological sensors have been employed in game-related studies in order to investigate various aspects of player behavior, such as flow state [11], stress management [12] and learning [6,13]. Particularly, Steinrucke et al. [6] use Shimmer3 GSR+ [14] wearable physiological sensors to assess the effect of stress on analytical skill performance during crisis management scenarios in the Mayor's Game. They show that stress induced through time pressure has an effect on players' analytical skills, while they attempt to unobtrusively measure players' experienced stress levels through physiological sensor signals.

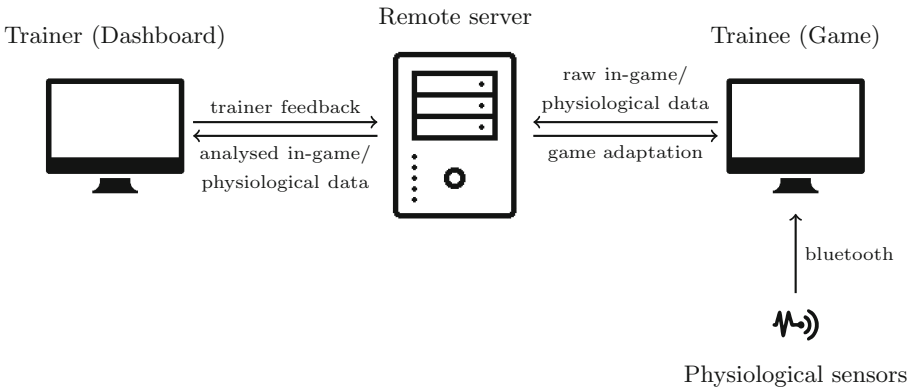

Fig. 2. Andromeda's architecture design. Two remotely located computers run the monitoring dashboard and Mayor's game respectively, while they both independently connect to the remote server. The physiological sensors are connected to the computer running the Mayor's game via bluetooth.

3 Approach

We have implemented Andromeda, a personalised crisis management training toolkit, based on crisis scenarios built for the Mayor's game. Andromeda includes a web-based monitoring and adaptation dashboard, and a remote data server. We have designed Andromeda aiming towards fully remote crisis management training using a centralised architecture, where the remote server undertakes the task of receiving, securely storing, analysing and serving in-game, physiological sensor and game adaptation data. The Mayor's game and trainer dashboard can be run on separate remote locations, connected to the server through persistent two-way connections. The physiological sensors are attached to the trainee and communicate to the remote server through the trainee's computer via a bluetooth connection. A graphical explanation of Andromeda's architecture is illustrated in Fig. 2. Below, we present a detailed description of each of Andromeda's main features.

3.1 Trainee Monitoring and Training Personalisation Dashboard

The trainee monitoring and training personalisation dashboard allows trainers to observe and dynamically adjust crisis management training sessions to the individual trainee, and is illustrated in Fig. 3.

The dashboard is web-based and runs on any modern web browser. Looking at Fig. 3, we identify four main features:

Training Session Controls. In order to allow fully remote monitoring of each training session, we provide a number of basic controls. In the dashboard's top bar (colored area), trainers can select the current user (trainee) from a dropdown

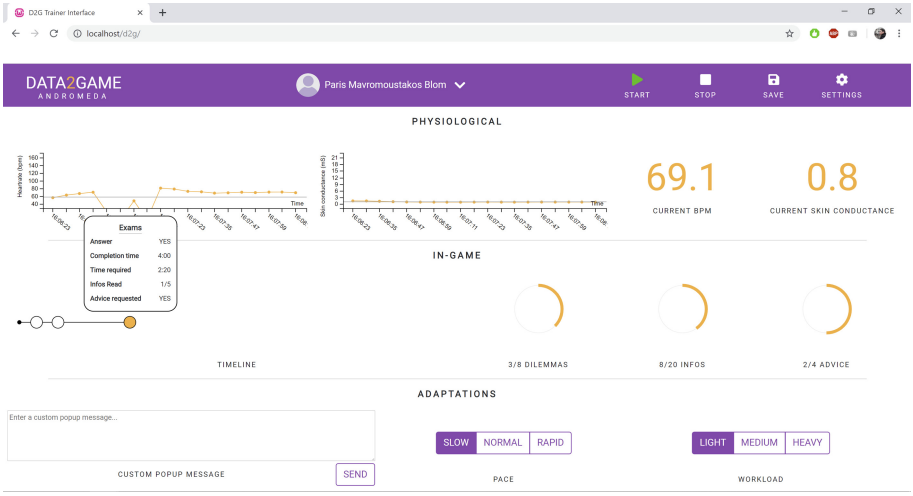

Fig. 3. Andromeda's trainer dashboard, during a crisis management training session. The participant's physiological responses are illustrated in the top third of the dashboard, followed by in-game monitoring (middle third) and adaptations (bottom third). (Color figure online)

menu. Using the four buttons on the right side, trainers can either (1) start training session monitoring, (2) stop/pause training session monitoring, (3) save the current training session to the remote server and (4) change the dashboard's settings (change the data request interval and line chart range).

Physiological Data Visualisation. We aim to manipulate trainee stress levels, in order to achieve a realistic crisis management training environment. To that end, we offer trainers the possibility of monitoring trainee physiological measurements, including heartrate and skin conductance. In the top third of the dashboard (labelled "Physiological"), two line charts are used to visualise the trainee's physiological measurements (heart rate and skin conductance). For these two signals, baseline measurements are extracted before the start of the training sessions, and are illustrated by a horizontal grey line in each respective line chart. Moreover, the current heart rate and skin conductance are illustrated through a large colored text on the right side. We expect the provision of information on trainee physiological measurements to guide trainers towards more effective training scenario adaptations.

In-Game Action Tracking. Apart from monitoring trainee physiological measurements, we provide information on the trainee's in-game actions. Since trainers can monitor training sessions remotely, it is important for them to have an overview of the current crisis management training scenario. In the middle third of the dashboard (labelled "In-game"), we have implemented a timeline (left side) which visualises the trainee's in-game actions. For each dilemma that is

answered, a circle is added to the timeline, which the trainer can hover over to retrieve detailed information on that dilemma's metrics (dilemma title, selected answer, dilemma completion time, time required to answer, number of advisor information read, whether advice has been requested). On the right side, three progress bars illustrate overall metrics on the entire training scenario (number of dilemmas answered, number of advisor information read, number of times that advice was requested).

Adaptation Options. One of Andromeda's goals is to create a personalised crisis management training environment. To that end, we allow trainers to adjust certain in-game variables, in order to tailor the current training session to the trainee's physiological and in-game behaviour. In the bottom third of the dashboard (labelled "Adaptations"), trainers can use a text box to write and send a custom message to the Mayor's Game which will appear as a pop-up to the trainee. This text box can be used by trainers to provide real-time, individual-level feedback to the trainees. On the middle and right side, trainers can adapt the scenario pace (speed in which advisor information is presentented to the player) and the scenario workload (amount of advisor information presented to the player).

3.2 Remote Server

The second essential part of Andromeda is the remote server. It is built to receive, analyse, securely store, and serve all the data relevant to the training scenario. This includes physiological sensor data, player in-game actions and trainer dashboard interactions.

Specifically, as illustrated in Fig. 2, the trainer dashboard can either communicate to the remote server to receive training session data or dynamically adapt the training scenario. The trainee's computer can either send in-game and physiological data to the remote server, or receive in-game adaptations (generated by the trainer). The raw physiological signals received from the sensors, will be filtered and analysed by the remote server before being sent to the trainee dashboard.

It is important to note that every data block sent or received by the remote server is labelled with a timestamp, to allow synchronisation of data between the three data channels (Mayor's game, trainer dashboard and physiological sensors). This way, the completed training scenarios can be re-run and the generated data can be analysed in scientific studies.

3.3 Physiological Sensors

We employ physiological sensors to monitor trainee physiological stress responses. Our goal is to provide trainers with realistic, personalised crisis management training scenarios based on stress level manipulation. We expect training scenario adaptations generated by the trainee to have an impact on trainee stress levels.

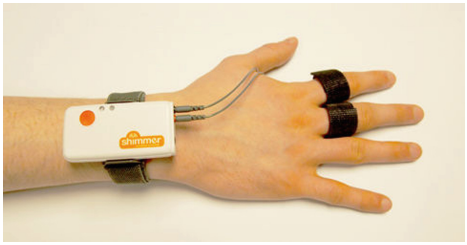

Fig. 4. The Shimmer3 GSR+ wearable sensor, with skin conductance electrodes attached to the index and middle finger.

We have selected to use the Shimmer3 GSR+ wearable sensors (Fig. 4), which are capable of measuring heart rate through photoplethysmography (PPG) and skin conductance (SC) through electrodes strapped to the trainee's fingers. Apart from PPG and SC, the Shimmer3 GSR+ sensors are equipped with a gyroscope, a 3-axis accelerometer, a thermometer and an atmospheric pressure meter. Connection to a computer is made possible through a built-in bluetooth transmitter.

4 Limitations and Future Work

We identify two main limitations regarding Andromeda's practical application. Firstly, this study mostly discusses crisis management training through decision making games such as the Mayor's Game. We consider the Mayor's Game a low-fidelity game, since it's text-based design cannot yield a highly realistic simulation of a real-life crisis. For that reason, we identify Andromeda as a tool which does not aim at replacing the current crisis management training scheme, but become a supplement of it. However, both Andromeda's dashboard and remote server are designed with generalisability in mind; with relatively little effort, they can be adapted to any type of game.

Secondly, remote crisis management training may prove to be a challenging task. Crisis management trainers and/or trainees may lack basic computational training skills, resulting in incorrect use of the dashboard and/or game engine, or misplacement of the physiological sensors. This can result in sub-optimal training conditions, so researchers are should ensure that the crisis management staff is provided with proper tutoring regarding dashboard, game and physiological sensor usage. Furthermore, various visualisation methods will be tested to ensure that crisis management trainers thoroughly understand the physiological sensors' output signals.

We plan on employing Andromeda in scientific studies and experiments. Our main focus is player multi-modal stress response modelling and automated dynamic scenario adaptation. To that end, we aim to collaborate with crisis management experts from the safety association Twente (Veiligheidsregio Twente) in the Netherlands. Our planning includes interview sessions with professional crisis management trainers, to discuss which data visualisations should be added

to or removed from the dashboard in order to maximise the efficacy of training sessions. Moreover, we will consult crisis management experts to identify which features of the Mayor's game can be used as stress-inducing mechanisms, in order to create a close to real-life crisis management training environment. Once indicated, those mechanisms can be integrated in the trainer's dashboard as adaptation options.

Previous studies regarding personalised crisis management training [3] and multi-modal player modelling [15] have been conducted by the authors. A study on multi-modal stress response modelling using a static (non-adaptive) version of the Mayor's game is currently being conducted. If accurate models of trainee stress responses are implemented, they may be employed by Andromeda in order to automate the personalisation of training sessions. Within the scope of the Data2Game project, parallel studies such as [16] focus on creating generating textual game assets for serious games in the crisis response field.

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