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META AI INTEGRATED WITH FACIAL EXPRESSION RECOGNITION IN GAMES

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Abstract. *Artificial intelligence is common in games, and in this age of advanced technology, there is now a way to balance the game dynamically using an AI called Meta AI. In this research paper we will explore the design of Meta AI in a First-Person Shooter (FPS) game and try to improve it by integrating it with Facial Expression Recognition (FER) technology because Meta AI works by predicting the player's emotions to make changes to the game's state with consideration to fear of losing and hope of winning – player's emotion. The goal of Meta AI is to shake a player's emotions by changing it towards an emotion that will increase the feeling of wanting to keep playing while keeping the game engaging and challenging to play.*
Keywords: Meta AI, Facial expression recognition, Artificial intelligence, Game balancing

1. **Introduction.** Games have been a popular entertainment tool in the past these decades. Whether it is free or paid, game designers always have to make something new to keep players entertained, willing and compelled to play their games, because games are naturally not needed or not necessary for life. One approach to this is by using Meta AI (Director AI), a way to do dynamic balancing inside the game by letting an AI control the game's state (such as weathers, enemies, items, and stories) to direct the player's emotions towards the one that the game designer designated, following the 2D emotions map proposed by [1] without the players knowing it. The goal of Meta AI is therefore not to adjust the difficulty in a way that the players can play comfortably regardless of experience but to influence player's desire to want still to play even if sometimes they lose the game [1].

The term of Meta AI as one type of AI was coined by Mizuno and Satoi [1] to explain the AI that controls the game. One example of a game implementing Meta AI is an FPS survival horror game called Left 4 Dead 2 (L4D2). In this game, from what can be observed in its AI debug mode during a playthrough, the AI controlled the game's state by referencing on the game's environment and the player's statistics (such as the player's remaining health or the number of bullets shot) to calculate each player's intensity. The AI will then decide whether to help players or to give more challenges, making every playthrough different. This increases the replayability factor of the game. We designed a Meta AI system integrated with FER in an FPS survival game that we have developed with the title "Surefire Survive". AI debug mode of L4D2 was used as a reference to design and develop the game. We used the game to evaluate our hypothesis that a Meta AI functioning with the help of FER technology will provide more user experiences than the one

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without the system. Players are generally more prone to changes in emotions while entertaining themselves with games, whether it is in a digital or physical form [2], which should help the Meta AI in perceiving emotions from players and do its job to shake players' emotions by changing it towards an emotion that will increase the feeling of wanting to keep playing while keeping the game engaging and challenging to play. To test our hypothesis in this research, a questionnaire will be made, which is based on the Game Experience Questionnaire (GEQ) [3], Game User Experience Satisfaction Scale (GUESS) [4] and Immersive Experience Questionnaire [5]. The goal of this research is to contribute to the field of Meta AI, as there is still no research done in Meta AI combined with FER technology. The rest of the paper is organized as follows. Recent work is discussed in the next section. The proposed game Meta-AI design is illustrated in Section 3, and the results are explained in Section 4. Finally, conclusion and future work are discussed in Section 5.

2. **Related Work.** People are defining facial expressions as a change in facial condition due to several factors (such as emotional states or social communication) [6]. A combination of facial expressions will produce what we call emotions. There are six universal emotions inside each human, as declared by Friesen and Ekman; those emotions are anger, disgust, fear, happiness, sadness, and surprise [7]. Facial Expression Recognition (FER) is a technology that can read the facial expressions on people as Facial Action Units (such as chin raises, and inner brow raises). FER will then conclude what emotions emerge based on a combination of those perceived Facial Action Units [8]. One example of FER technology is AFFDEX SDK which is a facial expression recognition toolkit that can be used efficiently with a wide range of other software, using the Viola-Jones algorithm to detect faces, the AFFDEX will define the value of the Facial Action Unit (FAU), ranging from 0 to 100 for every FAU. Using those values, AFFDEX can then conclude what emotion happens at the time (disgust, fear, surprise, joy, contempt, anger, and sadness). Those emotions will also be assessed, between 0 to 100, to represent the intensity of those emotions [9]. Several studies are also found using FER as a tool to measure user experiences [8,10,11]; for example, there is a study on a facial expression recognition software called Facereader, developed by VicarVision and Noldus Information Technology, which is tested by Zaman and Shrimpton-Smith in their research to find the value of Facereader on measuring emotion to evaluate user experience. The result of this research is that Facereader can be a useful tool of measurement for user experience evaluation even though it needs help from the researchers to differentiate the subtle changes in expressions [12]. There is also another study using FER. This study used FER as a data collection tool with a mobile game application they developed called Emojive!. In Emojive! the player has to present a fitting facial expression from the given picture, and it will then decide whether the facial expression is correct or not with a useful visualization of emotion scores. This approach with a simple game user interface and real-time emotion recognizer proves to be an effective method in collecting emotion data [13]. One study also shows that FER can be a tool for Autism Spectrum Disorder (ASD) children to develop the ability to show expression in a game called My Drama by using facial expressions as input, where there are four steps to make a facial expression that can be defined as emotions learning. First, players must collect emotion medals to learn the various emotion scattered across the scene. Second, players must choose the right facial expression from the given order. Third, players must give appropriate expression based on the context of the given scene where the game will use FER to judge whether the expression given is correct or not to advance to the next scene. Lastly, in the final act of the game, players need to capture photos of others' faces with certain emotions for social interaction purposes [11,14].

Meta AI is one of the methods available for a game designer to balance the game dynamically, increasing the game's replayability factor by assigning an AI that decides how the game will progress when played by dynamically changing the game's state. Meta

AI is not a character AI; although it works similarly to character AI, one of its jobs is to control the character AI while also controlling many other game variables. Meta AI's job depends on an affective design that observes and predicts players' emotions to influence players into certain emotions while avoiding certain other emotions. This is done so players can always have a satisfying and funny experience in every playthrough even if they lose the game [1]. Several games have been implemented with Meta AI, although there are not many who have successfully implemented Meta AI because the implementation is quite challenging and must be designed by ad-hoc [1]. Structurally Meta AI is made up of 3 primary components: World Analyzer that captured the game's situations and player's emotion or stress level, a Game Maker, that listed out possible decisions from the data received from the World Analyzer, and an Operation Generator, that executes the decision made by Game Maker into the game world. Having all three components working correctly in a game will hypothetically enable it to change its state dynamically, resulting in the game able to give a helping hand to players or giving them more challenges, all of which is done to influence the players' emotions during the playthrough. Meta AI can only work as intended in a game where the goals are distinct and clear for every stage, which gives both the feeling of fear of losing the game and hope of winning the game for players. Therefore, Meta AI works better for games within the fighting, FPS, and card game where the climax of the game is both attainable but also challengeable which makes it fun even if the player loses the game. This is also the reason why Meta AI can influence the player's feeling to keep playing [1]. However, there is no empirical evidence in how Meta AI enhances the player's experiences; hence, this paper aims to provide the empirical evidence in the effect of Meta AI implementation in the game to the player's experiences.

3. **The Meta AI Design.** The first phase of this research is analysis and review. In this phase, we design our own Meta AI, referencing from L4D2 as well as designing the game itself. The level design of the proposed game is illustrated in Table 1. In this game giving the player, a distinct goal and a high score have the purpose of giving the player a feeling of accomplishment. The working Meta AI design for this game will be primarily focused on changing the difficulty between what we labeled as state Build Up 1, Build Up 2 and Build Up 3, continue to Peak state and then Relax and back to Build Up this observation goal as described in Table 2. Following the framework, as stated above, we design the working 3 Meta AI components. The first component, called World Analyzer, will observe

Table 1. The level design of the game

Stages	Description	Goals
Stage 1	The starting place of the player in this map. A simple stage where the player can immediately be able to go to the west and east of the map after going north from the spawn point.	Find 2 keys that were placed in west and east of the stage, to be able to proceed to the gate that will be open on the north side of the map. Enter the gate to proceed to stage 2.
Stage 2	This stage is a maze made up of a settlement that combines with the night environment and has the goal of confusing the player.	Exit the maze. Upon exiting the maze player will continue to the final stage.
Final Stage (Checkpoint B)	This stage is a Royal tomb of the dessert where there is a pyramid, etc. The Mighty Troll inhabits this place, the boss of this map.	Survive the onslaught of the Mighty Troll and its goblin underling for 5 minutes.

TABLE 2. Observation goals for the design of working Meta AI

Emotion: Nervous Stressed Situation: Pressure Negative BUILD UP 1 STRESS Level GOAL: 100%	
HP left	Low
Total Ammo	Low
Total Enemy spawned	High

Emotion: Excited Elated Situation: Pressure Positive BUILD UP 2 STRESS Level GOAL: 50%	
HP left	Mid
Total Ammo	Mid
Total Enemy spawned	High

Emotion: Depressed Bored Situation: Relaxed Negative (AVOID!) STRESS Level: 0%	
HP left	High
Total Ammo	High
Total Enemy spawned	Few

Emotion: Serene Relaxed Situation: Relaxed Positive BUILD UP 3 STRESS Level GOAL: 25%	
HP left	High
Total Ammo	High
Total Enemy spawned	Few

TABLE 3. The Operation Generator that works at spawning goblins

GOBLIN					
Status (Baseline)		**Enhanced (Meta AI)**			
		Situations based on 2D emotions map			
		Pressure Negative (Stressed Peak) (B1)	**Pressure Positive (Stressed Fun) (B2)**	**Relaxed Positive (Relaxed) (B3)**	**Relaxed Negative (Bored)**
Spawn Rate	1 enemy for every 3 seconds (0.167-0.667)	Increase in a steady rate capped at 100% increase (30 seconds)	Return to baseline status from either Pressure Negative or Relaxed Positive situations by either increasing or decreasing at a steady rate (10 seconds)	Decrease in a steady rate capped at 50% decrease (15 seconds)	This situation is the one Meta AI will try to avoid
Maximum spawned at a time (Total goblins in the map)	50 (25-100)	Increase in a steady rate capped at 100% increase (30 seconds)	Return to baseline status from either Pressure Negative or Relaxed Positive situations by either increasing or decreasing in a steady rate (10 seconds)	Decrease in a steady rate capped at 50% decrease (15 seconds)	

and capture numeral data from the player that will fill the stress level. The second component, the Game Maker, will be the one that decides which state the game will proceed on. The probability of all three possible states is the same as we want to observe the player's emotions and decision making in each state. This component will be designed in a Finite State Machine (FSM) (see Figure 1). The third component the Operation Generator will change the difficulty (see Table 3). In this single-player survival game, the difficulty can change based on the numbers of mobs that will be coming when the horde is triggered hence the Operation Generator working this way, with FER working with captured emotion of joy and anger to increase the stress level. The equation for the stress rate (SL) is

$$SL = SM + ((HP + AM) * FER) \tag{1}$$

where SM indicates the state modifier variable, HP represents the player's health point, AM indicates the level of ammo that player has, and FER represents the value of the

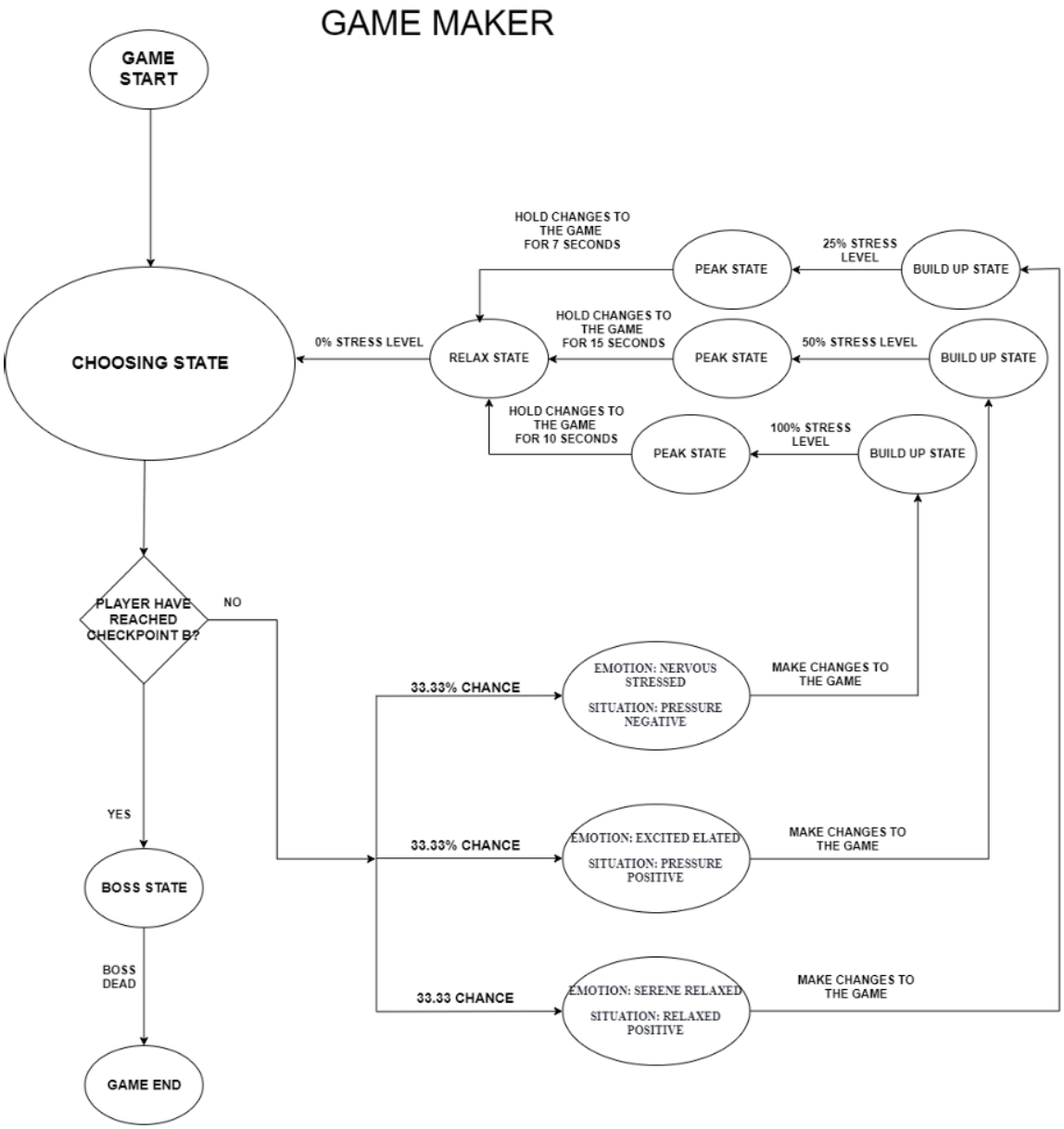

FIGURE 1. Game Maker component in FSM

player's FER confidence value captured by the camera. With this equation the captured emotions will boost or slow the stress rate and in turn. The proposed Meta AI will decrease or increase the difficulty of the game by hastening the stress level goal in every build up state. The second phase of this research is game development. In this phase, we develop the game based on the finished design from phase one.

The game was developed using the Unity game engine combined with FER technology from AFFDEX. The game titled "Surefire Survive" was finished following the design and for research purpose, we show debug mode of the game in a second monitor wherein it includes the FER captured emotions, player's face captured by the webcam, game environments that will be subject for observation for World Analyzer, and the state of game and player currently all in real-time so it can be observed. An example of this setup is showed in Figure 2.

The next phase of this research is the experiment and data collecting. In this phase, we invited participants for the experiment, which will be students from our university. Methods to prevent player's bias, in the experiment was done without telling the participants which type of survival game they played between one with FER and one without FER.

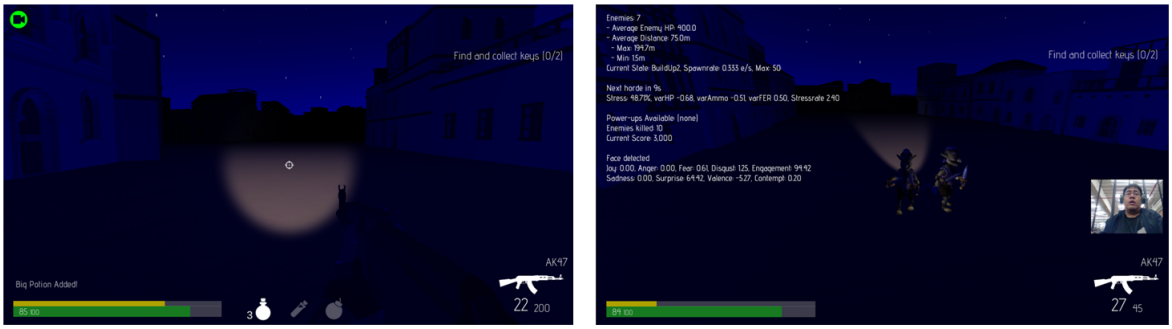

FIGURE 2. Game play from (left) first monitor and (right) second monitor

Participants will be divided into two groups: Group one will play the FPS survival game implementing Meta AI integrated with FER labeled as Experiment 1. Group two will play the FPS survival game implementing Meta AI but without FER labeled as Experiment 2. Participants from each group will need to answer the questionnaire that was prepared beforehand after they finished playing the game with three tries. Both questionnaires from each respective group will be compared to see the difference in user experience. The result, including data gathered and observed, will then be analyzed to form a conclusion from this research.

4. **Results and Discussion.** The experiment phase ends with 52 participants for each group with mostly male participants from ages 21 to 23, and 25 people participate in both groups. There are three methods used to prove the validity of the data collected. First is by matching the answer from the questionnaire with the observed variables from the second monitor. Second is by seeing the difference in the range of answers from the same component of data. Last but not least is by looking at the high score recorded in each playthrough. With the three methods of validating aforementioned, we found some outliers who answered the questionnaire inconsistently from the playthrough that was observed or giving false answer, hence the data of everyone we deem as outlier will not be used to make a conclusion from this experiment, the amount of 52 participants is the number we got after excluding all the outliers.

Kolmogorov Smirnov Test was applied to the data received from the outcome of the experiment to determine how the data were distributed, the result from this test was a p-value of 0.138 for Group 1 and p-value of 0.85 for Group 2, with $\alpha = 0.05$. In conclusion, from the Kolmogorov Smirnov Test, a p-value over 0.05 is accepted as data distributed normally. That means both Group 1 and 2 have data that were distributed normally, because of that we will proceed on using Paired Sample T-Test to find a significant difference in each component of the questionnaire to find a comparison of user experience between both groups and to prove our initial hypothesis. The conclusion of the Paired Sample T-Test to determine the comparison of data to have significant differences is a p-value under 0.05. The result is that two components were determined as having significant differences. Those two components were Tension and Positive Affect, Tension is a component for Q10 and Q11, with Q10 having a p-value of 0.008 and Q11 having a p-value of 0.063. On the other hand, Positive Affect is the component for Q16, Q17, and Q18, with Q16 having a p-value of 0.002, Q17 having a p-value of 0.008, and Q18 having a p-value of 0.01. From the result of data analysis for getting significant differences in user experience between an FPS survival game with working Meta AI integrated with FER and one without FER is that there were significant differences only on two questionnaire components out of 7 components, which are Tension and Positive Affect. However, this outcome was already expected as the result of the comparison of average from each component shown the same result (see Figure 3). The result of Positive Affect being higher in Experiment 2 than

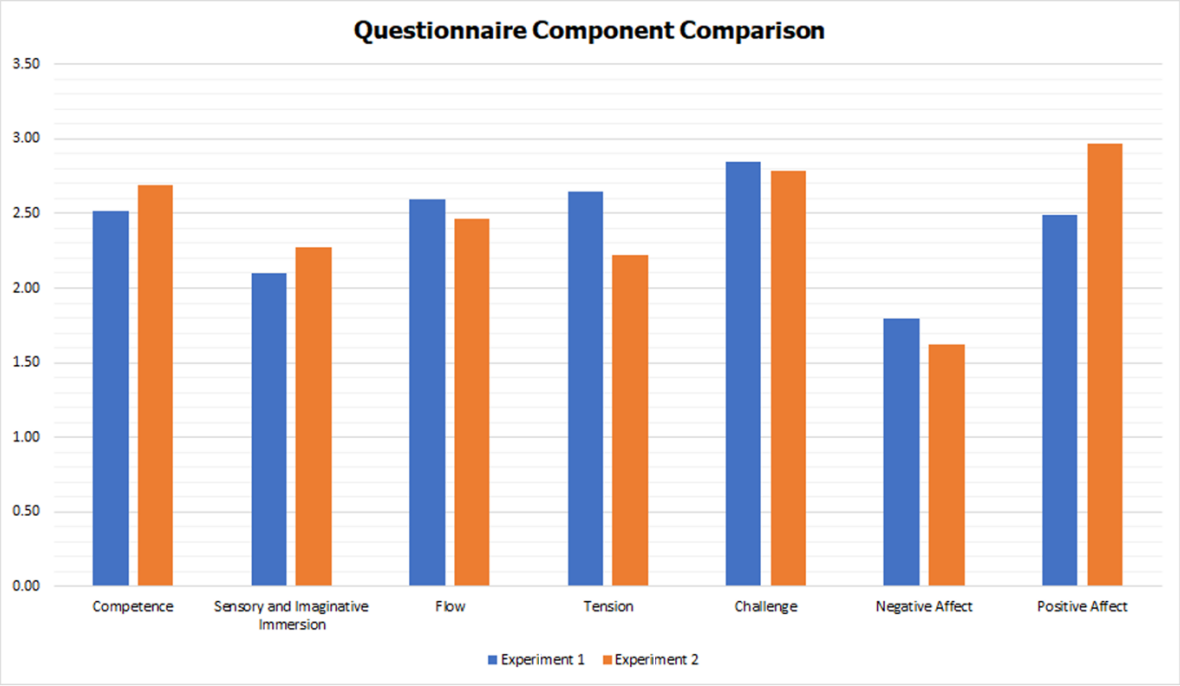

FIGURE 3. Average of each questionnaire component comparison

Experiment 1 is because quite a lot of participants participated in Experiment 1; then, after that doing Experiment 2 on a different day showed better progress in the game in Experiment 2 and answering the questions for Positive Affect better. The same thing can be said for Tension because of the same reason, the game element that incites Tension became less effective for the participants in the second experiment compared to the first experiment on a different day. The initial hypothesis of Meta AI working integrated with FER giving more user experience is not accepted in this research because after reviewing the result of data analysis, there are no significant differences between the FPS survival game with working Meta AI integrated with FER and without.

5. **Conclusion and Future Work.** From the result of this research, we need to improve the design of the FPS survival game with working Meta AI and FER. We also need to review the approach the experiment phase was conducted if this research wants to be brought again. First, the calculation for the stress level was calculated in a matter of every second and from what we can observe and review, our game as a single-player FPS survival game does not compel most players to show many emotions, contrary to our review from a game we reference, the L4D2 game. Because of this, our design of the FPS survival game with Meta AI working integrated with FER might perform better in a multiplayer form where more than one player is doing the same objectives to clear the game together, that will incite social interaction which in theory will compel players to show emotions. Secondly, there might be a need to improve the calculations matter for stress level wherein the weight for FER will influence more variables. Lastly, our experiment was conducted without the reliability of participants' data because some participants participated in both experiments, and some did not, which needs to be avoided by making all participants participate in both experiments, or the two groups of experiments have all different participants. Moreover, at the end of this research, hopefully, it opens a new door of possibility in the field of both Meta AI and FER research.

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