Creating an Affective Fighting Game AI System with Gamygdala

Kaori Yuda
Active Knowledge Engineering Lab
University of Aizu
Aizuwakamatsu, Japan
s1240239@u-aizu.ac.jp

Maxim Mozgovoy
Active Knowledge Engineering Lab
University of Aizu
Aizuwakamatsu, Japan
mozgovoy@u-aizu.ac.jp

Anna Danielewicz-Betz
Ludwig-Maximilian University
EU Business School
Munich, Germany
anna.danielewicz_betz@euruni.edu

***Abstract*—State-of-the-art fighting game AI technologies are already able to play at the level of professional human players. Thus, the challenge is not only to create artificial opponents that can play on a par with people, but also to make them enjoyable to play against. This can be done to a certain extent by implementing traits of human-like behaviour, such as affective (emotional) decision-making. In this work-in-progress report, we show how the task can be accomplished. We rely on Gamygdala, an emotional appraisal engine, to model emotional states of the computer-controlled opponent, and use findings from psychology to translate emotions into actions.**

Keywords—affective AI, emotional appraisal, fighting games.

I. Introduction

Fighting games simulate a one-to-one combat encounter of the player with a human- or AI-controlled opponent. Most fighting games offer a choice of diverse characters with distinct physical characteristics and unique special attacks. Usually considered representative of action games, modern fighting games require both fast reaction and certain strategic thinking. Some authors study fighting as a complex real-time variation of the rock-paper-scissors game, since successful strategies require the players to predict and counteract actions of their opponents [1].

Therefore, designing a strong AI for fighting games is not an easy task, with fighting being successfully used as a game AI competition platform [2]. However, recent research efforts in this area show that state-of-the-art methods already allow to develop artificial agents able to compete with professional gamers [3]. Thus, creating sufficiently strong AI-controlled non-player characters (NPCs) can be considered a solved problem for most practical game development purposes. The challenge now is to create *fun* artificial opponents, providing enjoyable player experience. Indeed, facilitation of player immersion by means of credible and adaptive AI opponents is often mentioned as a primary goal in recent publications on fighting game AI [4, 5].

It is generally presumed that people enjoy playing against other people because they behave in a certain "human-like" way that is perceived as inherently enjoyable. (Social aspects of player-versus-player [PvP] games are perhaps even more important, but they are outside the scope of our work.) Thus, "fun AI opponents" should possess certain human-like traits, such as adaptability to opponent actions and recognisable play styles.

The present work aims to implement one major trait of human-like behaviour, namely *affective* (emotion-driven) decision making. We presume that when NPCs are capable of exhibiting emotion during fights, the game is more enjoyable for human players. In practice it means that some actions of NPCs will be triggered by changes in their simulated inner emotional state.

II. Fuzzy AI of Universal Fighting Engine

In the current work we rely on Universal Fighting Engine (UFE) — an open source framework for developing fighting games [6]. The framework includes a complete fighting game engine, written in Unity, and a set of customisable rooms and game characters. In particular, UFE includes "Fuzzy AI" — a flexible custom fighting AI system that can be fine-tuned to obtain desired character behaviour. According to UFE documentation, Fuzzy AI *"uses Fuzzy Logic to evaluate the information of the scene and calculate the desirability of each given action, translating the AI decisions directly into user input"* [7]. For us, the most important feature of Fuzzy AI is the presence of numerous tuneable settings that can be modified in real-time to adjust the behaviour of an AI-controlled opponent. Instead of designing our own AI solution, we aim to translate emotional reactions of an NPC into changes of Fuzzy AI parameters (see Table 1).

TABLE I. Selected Fuzzy AI Options*

Type	Name ***Description***
enum	Behaviour style: *Five grades from Very Defensive (1) to Very Aggressive (5)*
float	Time Between Decisions: *The minimum time taken to formulate a decision.*
float	Time Between Actions: *Time between executing each decision.*
float	Rule Compliance: *Forces the AI to be more systematic or more random.*
float	Aggressiveness: *Controls the preference of attack moves over basic moves.*
float	Combo Efficiency: *Controls how efficient a combo has to be to proceed with it.*
bool	Attempt inputs when down: *Try reactions even when the AI player is down.*
bool	Attempt inputs when blocking: *Try executing moves when the AI player is blocking.*
bool	Attempt inputs when stunned: *Try executing moves when the AI player is stunned.*
bool	Attack when enemy is down: *Keep attacking when the opponent is down.*
bool	Attack while enemy is blocking: *Keep attacking when the opponent is blocking.*

* adapted from:
http://www.ufe3d.com/doku.php/character:aiinstructions
http://www.ufe3d.com/doku.php/ai:advancedoptions

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III. Emotional Appraisal with Gamygdala

Broekens, Hudlicka and Bidarra [8] propose that the development of an affective game AI system can be assisted by a specialised *emotional appraisal engine*, integrated into a game similarly to a physics engine. This way, emotional modelling can be "outsourced" to an external system, based on established psychological theories. This idea of an emotional appraisal engine is implemented in a proof-of-concept system Gamygdala [9], currently available as an open source JavaScript library. We integrated Gamygdala into UFE using a .NET JavaScript compiler Jurassic [10], and established an interface between these engines to facilitate the emotional appraisal of AI-controlled UFE characters.

Gamygdala requires us to set up *goals* and *beliefs* of the characters in question. Goals are named states that the character wants to achieve and may have different utility values, indicating their desirability, with negative utility corresponding to an undesirable goal. Beliefs are annotated events that move the characters towards or away from their goals, thus affecting their emotional state. Each belief is associated with likelihood (used to describe uncertain events), its causal agent, and a list of affected goals and congruence values. There is also a concept of time involved: it is possible to inform Gamygdala about the amount of time required to further "cooling down" of emotions.

Gamygdala is designed for use in complex multi-agent environments where goals of different agents can be connected indirectly; the agents can be friendly, hostile or neutral to each other, and the information passed between the agents (such as rumours) can also be uncertain. Therefore, fighting represents a very simple game world from this point of view: there are only two agents involved, hostile to each other, and their goals are directly opposite, with no hidden or uncertain events. When requested, Gamygdala performs an emotional appraisal of a given agent, returning a list of numerical values that correspond to the intensities of individual emotions. This list includes 16 out of 24 emotions defined in the OCC model [11]. It is helpful to understand how beliefs affect emotions. For example, joy increases when a desirable goal succeeds or an undesirable goal fails, while resentment goes up when a desirable event happens to a disliked agent [9]. It is outside the scope of Gamygdala to decide how these emotions will then affect the actual behaviour of the game characters, as this is the task of game AI developers.

IV. Goals and Beliefs of UFE Agents

In the current implementation of our system, there are only six goals — all associated with the NPC:

1. Win by KO (utility = 1). The agent wins when the opponent's health level reaches zero.
2. Lose by KO (utility = -1). The agent loses when the agent's health level reaches zero.
3. Win by Points (utility = 0.7). The agent wins by points when the round is over, and the agent's health level is higher than the opponent's health level.
4. Lose by Points (utility = -1). The agent loses by points when the round is over, and the agent's health level is lower than the opponent's health level.
5. Keep High Morale (utility = 0.6). The agent's morale is affected by several ad-hoc events.
6. Keep Low Morale (utility = -0.6). This negative goal is handled analogously to the previous one.

These goals are related, but still distinct. For example, when the agent hits the opponent, thus reducing its health level, it increases its own chances of winning; however, the chances of losing stay unchanged as they depend on the value of the own health level rather than that of the opponent. Winning by points is a legitimate goal, but we want our agents to prefer the knockout victory. Yet, losing by points is as undesirable as losing by a knockout. The "Keep Morale" goals were introduced to deal with certain scenarios that are typically perceived as either pleasant or annoying by people (unsporting behaviour like overly evasive tactics can be an example of the latter case). We do not assign any goals to the human-controlled character, since these are associated with the same events and are mostly opposite to the goals listed above.

The emotional state of a given NPC is affected by the beliefs, as listed in Table 2. The emotional decay event ("cooling down") is generated once per second.

TABLE II. Beliefs of the AI Agent

Belief name (causal agent) ***Event trigger***	**Goals affected (+/–)**
Caused damage (NPC). *Occurs when NPC hits the opponent, reducing its health level.*	Win by KO (+) Win by Points (+) Lose by Points (–)
Received damage (Opponent). *Occurs when the opponent hits NPC, reducing its health level.*	Lose by KO (+) Lose by Points (+) Win by Points (–)
Spent time winning (Empty). *Occurs every second as long as NPC's health level is higher than the opponent's health level.*	Win by Points (+) Lose by Points (–)
Spent time losing (Empty). *Occurs every second as long as NPC's health level is lower than the opponent's health level.*	Lose by Points (+) Win by Points (–)
About to win by KO (NPC). *Occurs when the opponent's health is very low.*	High Morale (+) Low Morale (–)
About to win by points (NPC). *Occurs when time is running out while the agent has more health than the opponent.*	High Morale (+) Low Morale (–)
About to lose by KO (Opponent). *Occurs when the agent has very low health.*	Low Morale (+) High Morale (–)
About to lose by points (Opponent). *Occurs when time is running out while the opponent has more health than the agent.*	Low Morale (+) High Morale (–)
Made 3 successful attacks (NPC). *Three consecutive attacking moves of the agent were successful.*	High Morale (+) Low Morale (–)
Failed to attack 5 times (Opponent). *Five consecutive attacking moves of the agent were unsuccessful.*	Low Morale (+) High Morale (–)
Opponent is evasive (Opponent). *The agent failed to cause any damage for 10 seconds while receiving no damage.*	Low Morale (+) High Morale (–)
Opponent is very resilient (Opponent). *The agent received damage five times consecutively without being able to cause any damage.*	Low Morale (+) High Morale (–)

Choosing belief/goal congruence values can be tricky since one has to decide to what extent a certain belief blocks or facilitates a given goal on a scale [-1, +1]. Currently we use the following rules:

1. Caused damage/Win by KO:
   c[ongruence] = 1 – *OppHealth* / *MaxHealth*

2. Received damage/Lose by KO:
   c = 1 – *NpcHealth* / *MaxHealth*

3. Any belief facilitating or blocking Win by Points:
   $$c = \frac{RoundTime * (NpcHealth - OppHealth)}{MaxRoundTime * MaxHealth}$$

4. Any belief facilitating or blocking Lose by Points:
   $$c = \frac{RoundTime * (OppHealth - NpcHealth)}{MaxRoundTime * MaxHealth}$$

5. About to win by KO or by points:
   c(Keep High Morale) = 0.7
   c(Keep Low Morale) = -0.7

6. About to lose by KO or by points:
   c(Keep High Morale) = -0.7
   c(Keep Low Morale) = 0.7

7. Made 3 successful attacks (incremental event):
   c(Keep High Morale) = 0.2
   c(Keep Low Morale) = -0.2

8. Failed to attack 5 times, opponent is evasive, opponent is resilient (incremental events):
   c(Keep High Morale) = -0.2
   c(Keep Low Morale) = 0.2

Congruence values in incremental Gamygdala events are treated as relative contributions towards or against the goal.

V. Translating Emotions into Actions

Numerous studies confirm the impact of affect on decision making and judgement [e.g. 12–16]. Positive emotions tend to increase the deliberation, whereby more information is sought and risk avoided, while aroused states and negative emotions result in simpler decisions, increased risk and polarised judgment [17]. Emotions may further lead to biased decision making; with fear and anger, e.g., having significant (and opposite) effects on risk perception [18]. Generally, positive affect is associated with faster thinking and negative affect with the opposite [13]. Isen [19] argues that positive emotions facilitate systematic and careful information processing, resulting in more efficient and more thorough decision making. As important motivators, emotions clearly influence action [20–22]. Since we only take into account those affects that relate to the overall goal of defeating a disliked opponent, the rules of translating emotion into action are limited here to 9 emotions only, namely *hope*, *fear*, *fearsConfirmed*, *joy*, *distress*, *satisfaction*, *disappointment*, *relief*, and *anger*. For further discussion of the reactions triggered by these particular emotions, see, e.g., [23–31]. The rules for changes in fuzzy AI parameters, as triggered by each affect (when applicable), are listed in Table 3.

TABLE III. Emotions triggering Fuzzy AI options

Option	Rules
Behaviour style	See Figure 1
Time between decisions	higher hope, satisfaction, relief => *increase time between decisions, decrease aggressiveness* higher fear, fearsConfirmed, joy => *decrease time between decisions, decrease aggressiveness* higher distress, disappointment => *increase time between decisions, decrease or increase aggressiveness* higher anger => *decrease time between decisions, increase aggressiveness*
Time between actions	higher fear, hope => *delay action* higher disappointment, anger, joy => *execute action immediately, (instant gratification, lowered expectation)* or *delay action (deferred gratification, positive outcome)* higher satisfaction => *decrease time to action execution* higher relief => *increase execution time*
Rule compliance	higher hope, satisfaction, relief => *increase predictability* higher fear, joy, disappointment, anger => *increase randomness*
Aggressive-ness	higher hope, anger, distress => *increase frequency of attack moves* higher fear/fearsConfirmed, disappointment, relief => *increase frequency of basic moves*
Combo efficiency	higher anger, fearsConfirmed, distress => *decrease combo efficiency* higher joy, satisfaction, hope => *increase combo efficiency*
Attempt inputs when down	display of distress, fearsConfirmed and disappointment => *reduce aggressiveness, increase basic moves* (idle, hide); *increase time between decisions and actions*
Attempt inputs when blocking	display of fear and disappointment => *increase counter-attack moves and increase randomness*; success results in satisfaction, failure in anger => *in both cases increase attack moves*, with anger => *increase aggressiveness*
Attempt inputs when stunned	display of fearsConfirmed, distress, and relief (not dead) => *increase defensiveness and basic moves* (idle, hide); or (when triggering anger) => *increase aggressiveness/attack moves, and randomness*
Attack when opponent down	display of satisfaction, joy, and hope (to perform the mortal hit) => *increase attack moves, decrease randomness, increase combo efficiency*
Attack while opponent is blocking	display of anger and disappointment => *increase aggressiveness, increase attack moves, increase randomness* display of hope => *increase attack moves and combo efficiency, and decrease randomness*

Fig. 1 depicts our attempt at matching emotions with a behaviour style, from very defensive to very aggressive, with the horizontal arrows indicating an increase or decrease in aggressiveness.

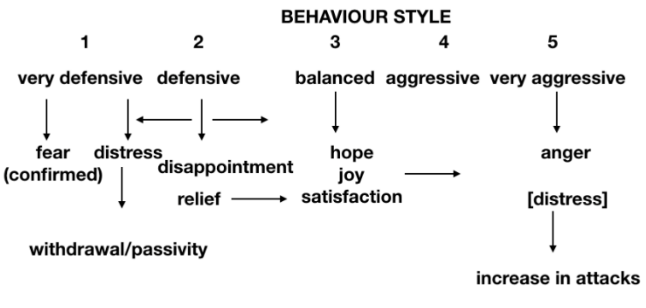

Fig. 1. Behaviour style continuum

VI. Conclusion

In this paper, we show how affective behaviour can be introduced into the fighting game genre to make artificial opponents more engaging for people. The emotional state of the computer-controlled character at a given time is modelled with Gamygdala, a system specifically designed for this purpose. This approach does not require a complete redesign of a game AI system: the knowledge of the characters' emotional states can be used to fine-tune the settings of ~~an~~

existing AI technology, such as Fuzzy AI of Universal Game Engine.

One challenging aspect of this work is to translate emotions into actions: it is necessary to understand first how different types of emotion affect actual human behaviour. We relied on findings from psychological research to design the rules presented. However, even a solid foundation does not guarantee any clear perception of emotional behaviour by the players, thus extensive testing and fine-tuning of the system are our next goals.

From the technical standpoint, the present project describes an example of practical experience of connecting a JavaScript-based module (Gamygdala) with a Unity-based game engine. The result can be of interest to a wider community of game makers, given high popularity of Unity as a game development instrument.

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