Health and Engagement Evaluator Model: a novel concept to evaluate a multi-person interaction

1st Luciana Machado Lins
dept. Computer Engineering
University of Pernambuco
Brazil
lml@ecomp.poli.br

2nd Pablo Barros
dept. Computer Engineering
University of Pernambuco
Brazil
pablovin@gmail.com

***Abstract*—This paper explores the complexity of human communication in multi-person interactions, focusing on the role of engagement in non-affective interactions. It introduces a model that uses an autonomous agent within the Perception/Action cycle to analyze and assess engagement during interactions in the Chef's Hat card game. The game provides a controlled environment for studying non-affective, competitive interactions, where participants' behaviors are categorized using Benne's functional roles and Clark's engagement density model. The proposed Health and Engagement Evaluator Model aims to measure and classify engagement levels and types to ensure healthy group dynamics. The paper highlights how machine learning can be applied to improve agent decision-making and enhance multi-person interaction outcomes.**

***Index Terms*—Engagement, Non-affective interactions, Autonomous agent, Group health, Perception/Action cycle**

I. Introduction

Human communication has played a crucial role in our societal evolution. Communication can take many forms, including writing, speech, gestures, and facial expressions, but the most complex type is face-to-face communication. This type of communication requires interactions with recognition of verbal language, tone of voice, facial expressions, and body language simultaneously.

A. The Multi-person Interactions

A multi-person interaction involves at least three participants and presents analytical challenges due to the complexity of emotional dynamics shaped by both the participants and their surrounding environment. As with other forms of interaction, it is essential to ensure that its objectives are met while preserving the well-being of participants. However, achieving this requires a good understanding of all the participants and the environment in which the interaction occurs.

A simpler way to evaluate and support these interactions would be to introduce an autonomous agent into the interactions. Agents can be represented by different forms — a robot or an avatar — and are used to interact with humans. This type of communication is called human-agent interaction and is defined by [1] in the Perception/Action cycle.

This cycle is used to define the interaction stages, as shown in Figure 1. It has features four stages: perception, prediction, action and outcome.

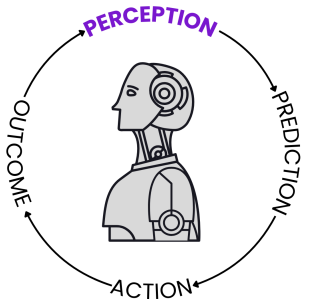

Fig. 1. The Perception/Action cycle

In the first stage, the agent gathers and extracts relevant information from environment and participants, which can include visual data (images and videos), auditory signals (sounds), and linguistic elements (language). This data is then processed using higher-level cognitive concepts such as personality, mood, and empathy, allowing the agent to develop a deeper understanding of the environment.

In the second and third stages, the agent analyzes its intrinsic state and determines the most appropriate action to take based on the given context. These stages involve processes that consider various environmental factors, ensuring that the agent responds in a way that aligns with its intended objectives and behavioral framework.

Finally, in the fourth stage, the agent receives feedback on the outcomes of its actions. This feedback allows it to refine its future responses, adapt to changes in the environment, and continuously improve its interactions over time.

As a first approach to a solution for a social perception/action cycle, in this paper focus on how the engagement could be used as a concept perception.This concept can be defined as a positive motivational state related to task-specific well-being. Thus, focus on the perception stage, the engagement of each participant is an effective to evaluate whether the objectives of an interaction were achieved.

In this paper, a proposed solution seeks to measure and classify the engagement with the intention to modulate the choice of actions to be taken by the agent for a multi-person interactions that do not have as main objective to promote

emotional connections. For this, the Chef's Hat game is used to analyze the interactions and apply as a concept in the perception stage of an agent.

B. The Chef's Hat

The Chef's Hat card game was developed to create an environment that makes humans and agents interact [2]. The game makes possible a competitive environment that promotes affective interactions. Given the predictable nature of the environment and clearer objectives, interactions tend to be more casual and less complex.

The main objective of the game is for players to discard as many cards as possible throughout the gameplay. The game begins with the distribution of cards, where each player receives a total of 17 cards. These cards represent various pizza ingredients, each assigned a value ranging from 1 to 11. In addition to these numbered ingredient cards, there is also a special Joker card, represented by the value 'J', that can take on any value depending on the player's strategy and the current state of the game. The design of these cards, including their visual representation and unique characteristics, is illustrated in Figure 2.

Fig. 2. Ingredient and the Joker cards, with their corresponding face number.

In the game, each card value is associated with a specific and equal number of cards. For example, there are two cards with a value of 2 and eleven cards with a value of 11. However, an exception to this pattern is the presence of only two Joker cards in the pack. In addition to the value 11 cards, the game includes a special golden card known as the 'Golden Muzzarella', which holds unique significance in gameplay. All these cards are played and discarded on a central board, as illustrated in Figure 3.

After the cards have been distributed, the person who possesses the Golden Muzzarella start the game. The remaining moves must comply with the following conditions: the number of cards played must be greater than or equal to the number of cards on the board, all cards played must have the same value, and this value must be lower than the value of the cards on the board.

When a player can no longer (or chooses not to) discard any more cards, they must pass. If no player can (or wants to) discard, the pizza is done and all cards on the board are removed to start a new shift with the remaining cards in the players' hands.

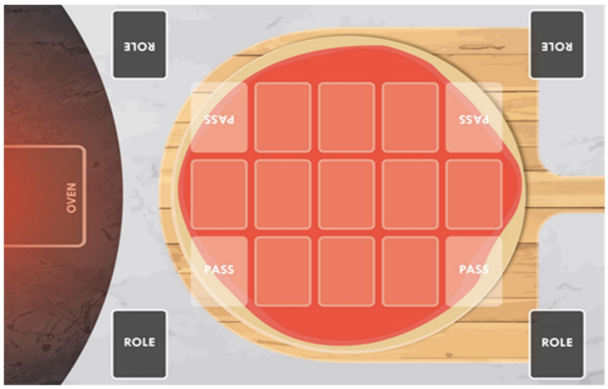

Fig. 3. The board game

As players manage to discard all their cards, a ranking is formed. To make the game more competitive and add layers to player interactions, the game presents a role-based hierarchy in a kitchen context: each player can either be a Chef, a Sous-Chef, a Waiter, or a Dishwasher. These roles is used to classify and give actions to each player according to the ranking. The table I shows the roles, to whom they are assigned and the action related in the start of the game.

TABLE I
ROLE-BASED HIERARCHY, ASSIGNED AND ACTIONS

Role	Assigned	Special Action
Chef	The first in the ranking	Returns two cards of his choice to the **Dishwasher**
Sous-Chef	The second in the ranking	Returns one card of his choice to the **Waiter**
Waiter	The third in the ranking	give their lowest- valued card to the **Sous-Chef**
Dishwasher	The last in the ranking	Gives the two cards with the highest values to the **Chef**

Whether a player has two Jokers at the start of the shift, they can choose to play their special action: in the case of the Dishwasher this is 'Food Fight' (the hierarchy is inverted), in the case of the other roles it is 'Dinner is served' (there will be no card exchange during that the Shift).

Therefore, the game explores different traits of interactions, though competitive, dynamic and hierarchy. These promote several forms of interaction between participants. In addition to it, the Chef's Hat enables to introduce an agent in a simpler way.

II. An Critical Analyses and Proposed Solution

Recent [3, 4, 5] present models to detect interactions base on stronger emotional ties.

Temperaments [3] and personalities [4], used in these studies, do not suit the context of Chef's Hat. Using these concepts to model perception, would require deeper interactions with strong emotional ties that reflect routine, like recurrent conversations between friends. However, Chef's Hat is a game where most interactions are brief, fast-paced, and centered on gameplay.

Engagement could be a good concept to analyze the interactions [8, 9, 10], however, by evaluating the quality and frequency of interactions throughout the game. The study [5] employ the Benne's categorization of functional roles [6] to model participants in a group conversation. Benne's categorization classifies categories: Group task roles, Group building and maintenance roles, and individual roles. In the solution proposed, it is defined as:

- Production Functions (Task Roles): These are task-oriented and focused on achieving the group's goals. They can propose new ideas and strategies, be an opinion seeker, or energizer.
- Maintenance Functions: These functions help keep the group cohesive and functional. They focus on the well-being and interaction of the members.They can provide positive reinforcement and praise, be an encourager,or an observer.
- Individualistic Functions: These functions focus on the personal interests of a group member rather than the group's goals. Individuals in these roles may act helpless to gain sympathy, behave aggressively, dominate discussions, or resist progress by being stubborn. These behaviors can disrupt teamwork and hinder the group's effectiveness.

These function roles presented in [5] can be adapted to classify the engagement type through the state participants and the group. Furthermore, to achieve the game's main objectives, participants' behaviors in an interaction can be classified as either engaging or non-engaging. Engaging behaviors fall under Group Task Roles or Group Building and Maintenance Roles, while non-engaging behaviors are associated with Individual Roles.

Besides modeling functional roles, the engagement density model from the Clark's model [7] is apply in the proposed solution. This model is presented in Figure 4 and contributes to define an engagement level.

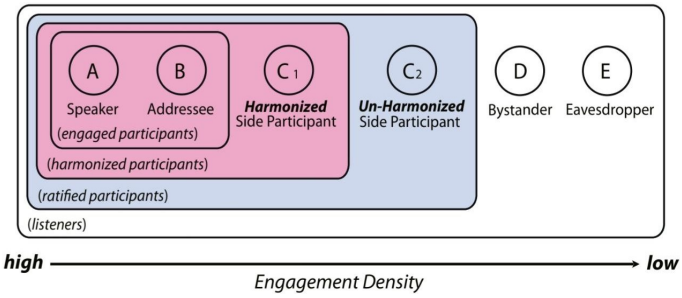

Fig. 4. Clark's model (1996) for a density engagement

Therefore, for the suggested approach, these two engagement metrics can be used to assess a novel concept, that is named group's health. It is important to establish the main objectives of interaction within the game and use them to promote healthy interactions and keep participants engaged. In the Figure 5, a diagram exhibits a Perception/Action cycle for the proposed solution.

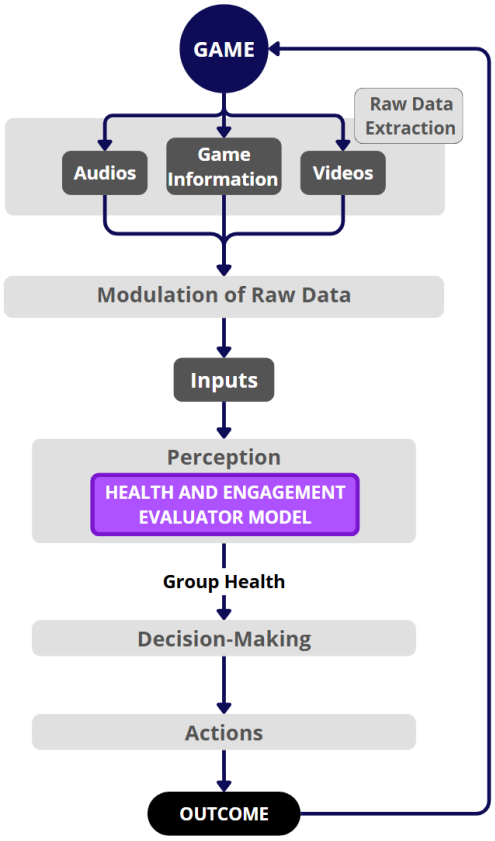

Fig. 5. Perception/Action Cycle Proposed

To measure the group health, steps are necessary that contain input modulation and machine learning models that define what interactions are happening in a certain moment, which of them are effective for defining group's health, and models to predict the engagement type and the engagement level from these interactions. The diagram illustrated in Figure 6 shows more details for the proposed model called Health and Engagement Evaluator Model.

III. Experimental Methodology

In first stage in the Figure 6, the inputs are processed, and social features are extracted. Through the audio, the prosodic features will be extracted. Additionally, a video of each participant and processed to obtain facial expression will be extracted through the game simulator. Information about the game - as cards on board, cards discarded, the number of cards in players' hands and role each player (if the round

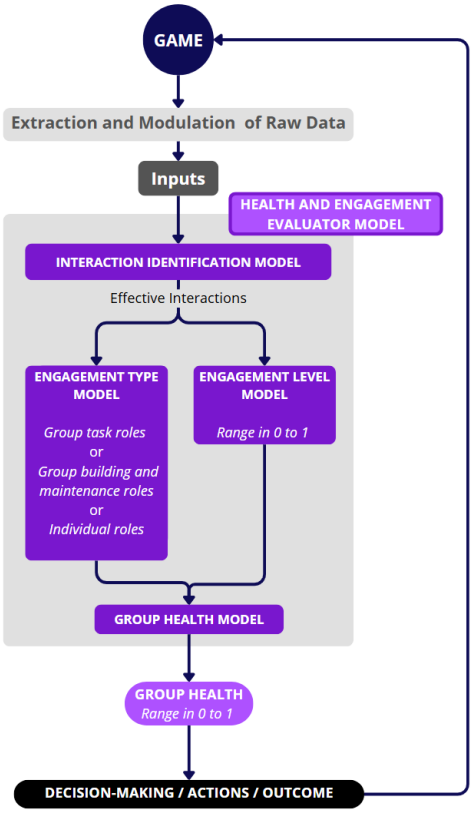

Fig. 6. Model for the Group Health

is not the initial one). Thus, the social features obtained are voice intonation, intention in speech, face expression of each participant, in addition to the game status. These features are extracted for each person on a game round.

The features will be used by a model that identifies the relevant interactions i.e. interactions that might carry any sign of engagement between the players. The interactions are measured between each of the participants with the player of the current move.

The selected interactions (effective interactions Figure 6) are used as input for the type and level of engagement models. The engagement level model will measure the engagement level interaction for each effective interaction in a range of 0 to 1. The engagement type model will classify each interaction using the function roles as categories. The output of the engagement models will be used by the group health model to analyze the group health that is measure in a range 0 to 1.

To train and validate these models, matches with a variety of human players will be recorded. Among these matches, specific rounds will be extracted and served to prepare social questionnaires to identify, player's engagement and group health. These questionnaires will be responded by different persons in order to obtain a variety of views on the different games.

IV. Conclusion

Human communication, particularly in multi-person interactions, is a complex process influenced by several factors, including verbal and non-verbal cues. This paper introduces an approach to analyzing engagement in non-affectives interactions by incorporating an autonomous agent using the Perception/Action cycle. This concept aims to facilitate the agent's perception of interactions, contributing to the agent's decision-making.

The Chef's Hat game is a propitious environment to study non-affectives interactions that allows the implementation of engagement evaluation strategies. Existing models, such as Benne's functional roles and Clark's engagement density model, provide a foundation for categorizing and understanding interaction patterns. The proposed Health and Engagement Evaluator Model integrates these concepts to assess group well-being and ensure health interactions.

Through experimental methodology, social and game-related features are extracted to analyze interactions and engagement. Through machine learning, the goal is to obtain engagement metrics for the group's health. This study helps in developing agents that are more adaptive and socially aware, promoting healthier and more effective multi-person interactions.

References

[1] Sun, R. and, Wilson, N. (2010). Motivational processes within the perception–action cycle. In Perception-Action Cycle: Models, Architectures, and Hardware, pp. 449-472). New York, NY: Springer New York.

[2] A. Ulizulfa, R. Kusumaningrum, R. Rismiyati and K. Khadijah, "Tem- perament detection based on twitter data: classical machine learning versus deep learning,"International Journal of Advances in Intelligent Informatics ISSN 2442-6571 Vol. 8, No. 1, March 2022, pp. 45-57. doi:10.26555/ijain.v8i1.692

[3] A. Ulizulfa, R. Kusumaningrum, R. Rismiyati and K. Khadijah, "Tem- perament detection based on twitter data: classical machine learning versus deep learning,"International Journal of Advances in Intelligent Informatics ISSN 2442-6571 Vol. 8, No. 1, March 2022, pp. 45-57. doi:10.26555/ijain.v8i1.692

[4] Y. Mehta, N. Majumder, A.Gelbukh and, Erik Cambria, "Recent Trends in Deep Learning Based Personality Detection," in Artif Intell Rev 53 (2020) 2313-2339. doi:10.48550/arXiv.1908.03628

[5] Y. Matsuyama, I. Akiba, S. Fujie, T. Kobayashi, "Four-participant group conversation: A facilitation robot controlling engagement density as the fourth participant," Computer Speech e Language ISSN 0885-2308 Vol. 33, Issue 1,2015,pp. 1-24, . doi:10.1016/j.csl.2014.12.001.

[6] A. Ulizulfa, R. Kusumaningrum, R. Rismiyati and K. Khadijah, "Tem- perament detection based on twitter data: classical machine learning versus deep learning,"International Journal of Advances in Intelligent In-

formatics ISSN 2442-6571 Vol. 8, No. 1, March 2022, pp. 45-57. doi:10.26555/ijain.v8i1.692

[7] Y. Matsuyama, I. Akiba, S. Fujie, T. Kobayashi, "Four-participant group conversation: A facilitation robot controlling engagement density as the fourth participant," Computer Speech e Language ISSN 0885-2308 Vol. 33, Issue 1,2015,pp. 1-24, . doi:10.1016/j.csl.2014.12.001.

[8] Y. Matsuyama, I. Akiba, S. Fujie, T. Kobayashi, "Four-participant group conversation: A facilitation robot controlling engagement density as the fourth participant," Computer Speech e Language ISSN 0885-2308 Vol. 33, Issue 1,2015,pp. 1-24, . doi:10.1016/j.csl.2014.12.001.

[9] Y. Matsuyama, I. Akiba, S. Fujie, T. Kobayashi, "Four-participant group conversation: A facilitation robot controlling engagement density as the fourth participant," Computer Speech e Language ISSN 0885-2308 Vol. 33, Issue 1,2015,pp. 1-24, . doi:10.1016/j.csl.2014.12.001.

[10] Y. Matsuyama, I. Akiba, S. Fujie, T. Kobayashi, "Four-participant group conversation: A facilitation robot controlling engagement density as the fourth participant," Computer Speech e Language ISSN 0885-2308 Vol. 33, Issue 1,2015,pp. 1-24, . doi:10.1016/j.csl.2014.12.001.