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Building SYMLOG profiles with an online collaborative game

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Abstract

Collaboration is essential for individuals working in groups to achieve a common goal. The understanding of the collaborative profile of each member of a team is extremely useful to understand and predict his/her performance in future teamwork. Users can demonstrate their collaborative skills in many digital platforms. Among them, video games enable to capture the players' behavior by the direct observation of their actions, while engaging them in a pleasant activity. In this work, we propose an approach for building collaborative profiles of a group of people working together towards a common goal, using an online game as a shared environment and a well-known theory about groups' dynamics: SYMLOG. This profile can be useful to know which features each member should train to improve his/her collaborative skills and to predict the performance of the group. We validate our approach with 98 players to evaluate the similarity between the profiles generated with our approach and the profiles derived from the SYMLOG questionnaire, which is the usual tool used with this theory

Keywords: User Profiles, Online Games, Collaborative Skills, SYMLOG

1. Introduction

The concept of Group Dynamics refers to the components and processes existent in any group. In a more strict sense, it can refer to a given framework aiming at regulating interactions in a group. An approach to study group dynamics is the analysis of the interactions between the members of a group under study. An interaction is defined as the event that happens when an individual who belongs to the group reacts to a stimulus generated by another member of the group (Maisonneuve, 1998). These interactions, which can be observed and analyzed to extract useful information, can be thought as the unit of observable activities for all members of a group. In this context, group dynamics is defined as the interaction process in a group to solve certain task (Bales, 2000).

For a collaborative work to be successful, it is considered that group members must show certain features: generosity, respect, cooperation, unity, role assumption, responsibility and communication (Bales, 1983). Each individual shows these collaborative features to a greater or lesser extent; a group member with insufficient features presents individual behaviors, which have a negative impact on the group and hinder the achievement of appropriate group work (Piezon & Donaldson, 2005).

The construction of personal profiles containing relevant information about these features, which can be obtained from the observation and analysis of group interactions, allows us to study the quality of collaborative work. User profiles make it possible to improve the quality of a collaborative work by taking actions aiming at improving the specific collaborative features that each group member appears to have to an insufficient degree. For example, if a teacher knows that some student have problems in working collaboratively, he/she could possibly improve the performance of that student by assisting him/her when working in a group.

Nowadays, in many environments (such as enterprises, schools, universities, and government) people have to collaborate with partners located in different physical locations using online platforms. Many of these collaborative platforms provide the information needed to capture the collaborative behavior of the users. An example can be found in software enterprises where leaders frequently have teams of developers composed by members located in different regions. In this context, any previous knowledge of the developers' collaborative profiles could enable better organization of developing groups.

The hypothesis of this article is that, it is possible to automatically learn collaborative profiles from the observation of the individual's behavior when playing a game. As a theoretical model, we base our research on the Systematic Multiple Level Observation of Groups (SYMLOG), proposed by Robert Freed Bales to code systems for studying groups (Bales, 1983). SYMLOG provides specific artifacts, by means of a questionnaire, to measure the collaborative behavior of the members of a team and gives feedback about this behavior. The selection of a game to capture the profiles intends to reach those users that might not be able to use the traditional mechanisms provided by SYMLOG, i.e. questionnaires, for example children that might not be able to interpret the questions correctly. The profile built by our approach is plotted in a three-dimensional space showing the position of the player in the three dimensions of the SYMLOG space (field diagram). This position provides a description of the player's profile that can be used for self-reflecting on how to improve the collaborative behavior in future game sessions.

This article is organized as follows. Section 2 introduces SYMLOG, the theoretical framework that bases our approach. Section 3 presents some related works. In Section 4, we present our approach to build SYMLOG profiles with a collaborative game. Then, in Section 5 we describe the experimental evaluation performed to validate our approach. In Section we present some implications of our work and how it can be used to evaluate the collaborative profiles of users. Finally, in Section 7, we present our conclusions and describe future work derived from our approach.

2. Background

We chose SYMLOG as the theoretical background of our approach since it allows measuring the collaborative behavior of the members of a team with a strong theoretical underpinnings in social-psychological theory. SYMLOG was proposed by Robert Bales (Bales, 1983) after years of research monitoring members of diverse groups interacting with each other, with the aim of structuring each collaborative behavior into categories. Although there are other approaches with the same aim such as BECM (Bell and Morse, 2013) and triple task methodology (Bell, Mahroum and Yassin, 2017), SYMLOG is a well-studied theory with more than thirty-five years of maturity that has been related to other models such as Belbin's semantics roles of behavior (Hare and Baker, 2005) and Big Five theory of Personality (McCrae and

Costa, 1987). SYMLOG has been extensively used for describing and analyzing different aspects of small groups that can be derived from the interactions among their members, such as role patterns, group conflicts and formation of subgroups (Boëthius and Ögren, 2008).

SYMLOG can be defined as a theoretical and structural coding system, which assumes that group activities can be classified along three dimensions: dominance (U) vs submissiveness (D); friendliness (P) vs unfriendliness (N); and acceptance (F) vs opposition to authority (B). Analysis using SYMLOG can produce as a result a measure of the degree to which a person or group possesses these characteristics. These quantitative measures enable the graphical representation of profiles as circles in the so-called *field diagram*. The position of each circle in the field diagram represents the value for the dimensions Positive-Negative (P/N) in the X-axis and Forward-Backward (F/B) in the Y-axis. The diameter of each circle is given by the value for the dimension Upward/Downward (U/D), where circles with a bigger diameter indicate a higher value in the "Upward" direction. Figure 1 shows a field diagram with five reference circles. The most important circle plotted in Figure 1 is that labeled as "Most Effective Teamwork Core" that represents the ideal profile of a user working collaboratively. There is also a "Conservative Teamwork Side" for users having a relatively good collaborative participation in the group. Members whose profiles fall in the "Swing Area" may swing to one side to support one subgroup on a given issue and then support the other subgroup on a different issue.

The most used artifact to obtain SYMLOG profiles is by means of a questionnaire. This questionnaire consists in twenty-six multiple-choice questions (Table 1), with three possible answers (not often; sometimes; often) about their perception of themselves regarding different aspects (Bales, 1983). Table 1 additionally shows the direction affected of each SYMLOG dimension by each item, although this information is not provided to individuals.

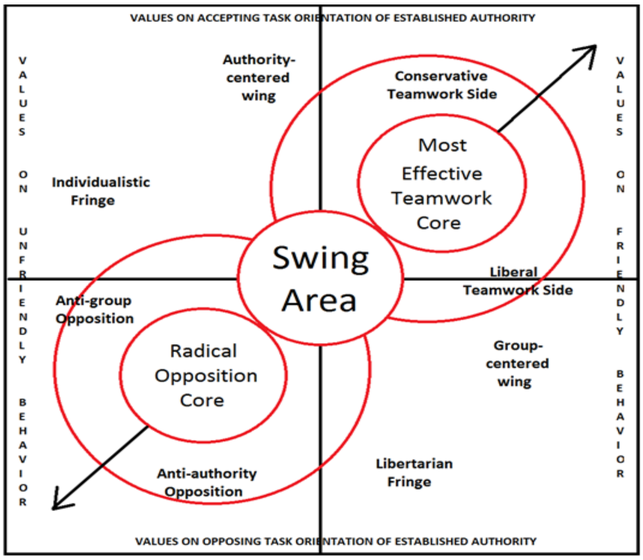

Fig. 1. SYMLOG field diagram (Bales, 1983).

Table 1. SYMLOG questionnaire.

Items	SYMLOG dimension affected
Individual financial success, personal prominence and power	U
Popularity and social success, being liked and admired	UP
Active teamwork toward common goals, group unity	UPF
Efficiency, strong impartial leadership	UF
Dogmatic enforcement of authority, rules, and regulations	UNF
Tough-minded, self-oriented assertiveness	UN
Rugged, self-oriented individualism, resistance to authority	UNB
Active pursuit of change, new and unorthodox ideas	UB
Leading group-centered efforts to change and seek new solutions	UPB
Friendship, mutual pleasure, recreation	P
Responsible idealism, collaborative activity	PF
Conservative, established, "correct" ways of doing things	F
Rigid adherence to group expectations and rules	NF
Self-protection, self-interest first, self-sufficiency	N
Rejection of established procedures, rejection of conformity	NB
Change to new procedures, different ideas	B
Group-centered approaches to new ideas and new procedures	PB
Trust in the goodness of others	DP
Dedication, faithfulness, loyalty to the group	DPF
Obedience to the chain of command, compliance with authority	DF
Grudging self-sacrifice in the interests of the group	DNF
Passive rejection of popularity, going it alone	DN
Admission of failure, withdrawal of effort from the group activity	DNB
Tolerance for new ideas and different procedures	DB
Comfort with others new ideas and suggestions for change	DPB
Giving up personal needs and desires, passivity	D

Among the limitations of SYMLOG, we highlight the level of interpretation required by individuals to complete the questionnaire, which prevents its application with young people and children. Furthermore, the instructor using SYMLOG needs to be familiar with the underlying theory, which can be relatively complex. Finally, the instructor needs to hand-score the behavioral coding to build the field diagram, which is time-consuming. We believe that our approach overcomes these limitations by providing an enjoyable environment in which the behavior of participants can be capture by automatically observing their interactions.

SYMLOG has been extensively used for the analysis of group interactions in different scenarios. For example, Bale´s model has been used in the study of work meetings, analyzing in detail the different kinds of interactions and generating individual reports about the behavior of participants, including qualitative information about group dynamics that might be used to improve the efficiency of group work (Pianesi et al., 2008). Another work in this context is the Mood Meter System (Rein, 1991), in which a compact graphical notation is developed to represent the fluctuations of the mood of the participants of a group work activity; the quality of the results obtained from the use of this system presents, too, a great dependency on the mapping model that is used to translate participation and moods into SYMLOG's variables. Losada and Markovitch (1990) proposed and developed the tool named "GroupAnalyzer", which is a computerized system to code and analyze group meetings. This system consists of two modules: a codification module for the creation of entries in the meeting protocol and an analysis module to study these meetings using SYMLOG; this allows for the detection of dysfunctional practices in meetings. Chen (1997) used SYMLOG to study cooperative virtual interactions in virtual communities, generating diagrams for the analysis of cooperation dynamics. The work presented by Rienks & Heylen (2006) only focused on the Dominance vs Submission dimension (U/D) of SYMLOG and contrasted the direct observation of the interactions of the participants of a meeting with the data of the SYMLOG questionnaires. Using Support Vector Machine (SVM) they obtained 75% precision in calculating the dominance of the individuals observed.

To the best of our knowledge, there is no previous work that used a game as a means for building SYMLOG profiles. The observation of game-based interactions to this aim is a novel approach, where profiles can be built automatically from the direct observation of the players' behavior. In this way, the proposal leads to a non-invasive playful alternative for the construction of profiles.

In the following section, we describe some related approaches using serious games to capture different aspects of the user behavior.

3. Related work

Games are structured environments with clearly defined rules, where players have clear goals and challenges, usually with victory as the ultimate goal. Players engaged with games are able to participate in simulated experiences without facing risks, generating higher engagement and improving their performance over time (Kirriemuir & McFarlane, 2004).

Games used for a purpose other than entertainment are known as *serious games*. The idea is to use a game environment to create a better understanding of a particular concept, to train or educate users, or to promote a product or service in an engaging and entertaining way. Serious games differ from *gamification* which refers to the concept of using games design elements (such as personal profile, non-fixed structure, challenge, feedback, short cycle time, competition, cooperation, chat-based social network, cooperation, theme) in non-game situations in order to enhance motivation and influence behavior (Deterding et al., 2011; Barata et al., 2013). Gamification and serious games have similar goals, but the difference resides in the context in which game elements are applied. The concept of gamification is wider than the concept of serious games since it applies game thinking and mechanics into non-game environments.

For a systematic survey on the use of gamification involving interactive systems and human participants, readers can refer to the work by Seaborn and Fels (2015). Seaborn and Fels (2015) outline current theoretical understandings of gamification and draw comparisons to related approaches, including games with a purpose, alternate reality games and gameful design.

In this paper, we explore the use of a collaborative game with the aim of building collaborative profiles of the participants with an unobtrusive and engaging activity. Although there are plenty of works focused on the use of serious games or gamification, few of them have focused on the learning of collaborative profiles.

Linehan et al. (2009), for example, proposed a series of foundations for the mechanics of a game for the training of "soft skills", whose features make it optimal for stimulating collaborative participation and communication between users. They also described which specific parts of such mechanics play an especially important part, for example, the introduction of "feedback phases" during the games, which enable a tutor to detect collaborative conflicts and help solve them. This mechanics was used in the development of DREADED, a game that proposes an innovative teaching method enabling users to train their social skills in a virtual environment (Haferkamp et al., 2011).

Kosterman & Gierasimczuk (2015) used a serious game in combination with the participation of users in social networks to influence the learning behavior of players. The focus of this research was in collaborative games, used as a strategy for reinforcement. Authors proposed an iterative model of learning that follows the procedures of network communication, belief aggregation, and gameplay and reinforcement learning, concluding that interaction in specific social networks can positively influence the learning behavior of players in a cooperative game.

These related works based their research in ad-hoc approaches to model users, without a base theory to study the groups' dynamics. In our work, we base our research on a well-known theoretical model widely used for group dynamics.

A similar approach that used games for the construction of user profiles is the research presented by Feldman et al. (2014). Authors implemented a set of games for the automatic construction of perceptual player profiles. Based on the profiles learnt by the system, the teacher can adapt the course by grouping students with a similar perception type in search of better performance. Authors proposed a Bayesian network to capture the information observed from the player performance in different game sessions. Differently, our approach does not model a player acting in isolation, but seeks to generate profiles of players interacting in a group playing a collaborative game.

In the next Section, we describe our approach for learning individuals' collaborative profiles from their participation in playing a serious game.

4. Building profiles with a collaborative game

In this Section, we describe in detail our approach for building collaborative profiles from the observation of the players' behavior in an online game. First, in Section 4.1, we describe the most important features of the game implemented to this aim. Next, in Section 4.2 we describe the procedure to learn SYMLOG profiles with the developed game. Finally, in Section 4.3 we describe in detail the model that maps game actions to SYMLOG values.

4.1. Development of a collaborative multiplayer game

Zagal et al. (2006) provided a noteworthy analysis on collaborative games, i.e. games in which all players must actively cooperate to win, by the achievement of a common goal. They identified a set of lessons and difficulties in the creation of collaborative games, focusing on the game "Lord of the Rings" *by Reiner Knizia's* (Knizia, 2004). The game designed by Knizia is an effective collaborative game because players are tempted to behave competitively but winning the game requires them to behave collaboratively. This game requires an active communication among the players and timely sacrifices for the good of the group. Since a good performance is extremely dependent on good communication and cooperation between the players, we agree with Zagal's claim that this board game is an appropriate choice for the study of collaborative skills. We developed an online version of the "Lord of the rings" board game (Fig.2) following the available rules[1] and taking special care to Zagal's recommendations:

- Each player has an individual marker, and earns points by helping the group. For example, players can earn points by participating in the task resolution, or can be selfish and only collect resources;

[1] https://www.svet-deskovych-her.cz/download/rules/LOTR_En.pdf. Accessed on April 2018.

- Each player can act and move freely within the possibilities offered by the game. Players are not required to participate in a certain form, although some actions are only possible through the consensus of other players;
- The results of decisions are always visible to the players, for example, a player can help to avoid an undesired event or he/she can use his/her turn to collect resources. If he/she decides not to help with the group task, the group may not be able to avoid the undesired event, which will make it difficult to achieve the goal. The selfish player, however, will have gained an additional resource.
- Provide players with heterogeneous resources (such as special cards) to distinguish different abilities and responsibilities.
- The nature of the game prevents that all the responsibilities fall in only one player;
- Since all players win or lose as a group, each player is motivated to play collaboratively;
- Although the core of the game does not change, each game session face the players with different scenarios. Then, when a player plays multiple sessions the exhibited behavior will help to improve the profile;

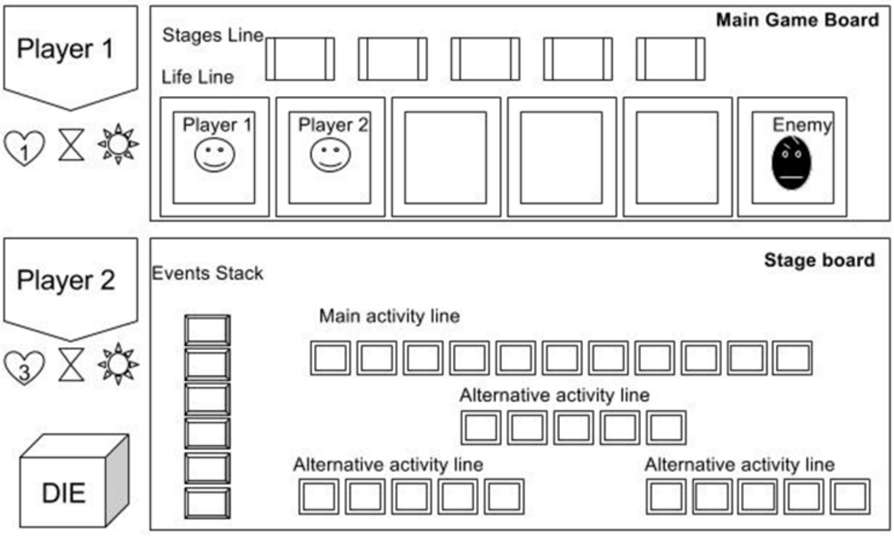

Fig. 2.Distribution of different elements in the collaborative game board selected. The Stage board changes when players move through the Stages Line in the Main Game board.

The developed game requires players to register with a username and password that enable us to individualize players in the experimental process. When a new player registers in the game, he/she is required to complete the SYMLOG questionnaire (refer to Section 2 and Table 1). When a player logs in he/she can create or join game session proposals (rooms). A game session can start once a group of at least two players joins the same room. According to the rules, the game can be played by 2 to 5 players. During the game, participants are represented with a nickname generated by the system so that they are not aware of the identity of the other players. When a game session is finalized (either by winning or losing), players can start or join a new game session.

The game has also a supervisor mode with access to a configuration screen in which different parameters of the game can be configured and statistics regarding the profiles of all registered players can be observed. Players can also view their own profiles, along with a brief description, when they log in to the application.

Respect to the game features, the players use representations of elements from the original board game: cards, a special dice, boards, tokens, etc. Players have resources associated to themselves (for example, a player has a set of cards; only that player can play or discard such cards) and certain attributes (for example, each player has a “health” indicator which, if it reaches a certain value, can cause the elimination of that player from the game session).

The goal of the game is to transport a precious object to the last scenario. To achieve this goal, players must advance through several scenarios avoiding obstacles. In addition, an enemy stalks their way during the game advancing in the direction opposite to the players. In order to avoid facing with the enemy and to advance in the road, players must take both individual and group decisions in each turn. These decisions lead to the achievement of the group's primary goal, possibly at the cost of individual sacrifices. For example, in order to advance through the scenarios or to prevent the enemy from advancing towards the players, players must have previously collected different elements.

In each scenario, the precious object is assigned to a different player, according to a health level of the players. If the enemy reaches the same position of the player who is holding the precious object, the game is over. Otherwise, if the enemy reaches the same position of a player who is not holding the precious object, only that player dies, but the game continues. However, most of the progress in this game is shared among all players: the group must complete a given number of scenarios to win the game, and the progress made on each scenario is common to all players. That is, the players have to solve certain tasks as individual players (for example, deciding whether to move one place in the road to improve his health level or to roll the die) and others tasks as a group (for example, to select which player should discard some cards). The balance between playing to benefit oneself and to benefit others must be kept during the game in order to achieve victory.

All relevant information about players and the initial state of the game is recorded; during the game, all information about the game actions (that is, any action taken by a player that modifies the game state in any way) is recorded too. This information is then analyzed to generate the players’ profiles. To this aim, we need a mapping model that translates different user behaviors into SYMLOG values. In the next section, we describe the way in which game sessions are used to build SYMLOG collaborative profiles

4.2. From game sessions to players profiles

In this section, we describe the overview of our approach to automatically and incrementally build a profile for each player based on his/her actions during the game.

Firstly, while the players interact with the game, the information about all actions that change the game state are logged along with the context in which the action was performed.

Secondly, after each game session, each action performed by the players is interpreted into a trinomial of SYMLOG values (one for each SYMLOG dimension). The mapping rules were defined by performing a careful analysis of each action and its consequences according to SYMLOG dimensions. This mapping was tested in initial experiments (Berdun, 2014) and the values were adjusted according to the expected results for different players used for testing purposes. In Section 4.3, we give further details regarding different action types and the mapping into SYMLOG dimensions.

At the end of the second step, we obtain a partial profile of the player that corresponds to his/her behavior in the game session that he/she previously played. Finally, in a third step, this partial profile is accumulated with player's previous profile and, at the end of the analysis, the final trinomials are weighted according to the number of interactions and normalized, with 0 representing the minimum value (negative behavior in the corresponding dimension), and 1 representing maximum value (positive behavior in the corresponding dimension). Since the duration of a game session and the use of a dice as part of the game has a direct impact on the number of interactions, we considered necessary that participants play more than once in order to better capture their profiles. Specifically, based on our experiments, we consider that a player must play at least four times in order to capture a profile reflecting his/her real behavior.

4.3. Mapping strategy between game actions and SYMLOG values

In this Section, we describe the methodology we follow to map each game action into a trinomial of SYMLOG values. To define this mapping, we carefully analyzed the nature of the game actions and the information that they give about the players' collaborative behavior. Each possible action of the game and its consequences in each possible context defined the final mapping to the SYMLOG values for each dimension. For this mapping, we considered the following factors:

- **Action type**. Most game actions consist of a choice that the player must take among several possible actions. Game actions may differ in the way these choices are made. There are three different types of game actions:
    1. *Turn Actions* are those that a player must perform in his/her turn. The player select to perform this action from a set of possible actions given the state of the game. These actions involve a single player, who has all the responsibility about the consequences of his/her choice.
    2. *Voting Actions* are those in which the choice is made based on the result of a poll between all the players. The final choice is the one chosen by the majority of players.
    3. *Optional actions* are those that a player can perform in his/her turn, anytime during the game. Examples of such actions are the use of a special card to prevent an event to happen, the use of a special card to double the points earned by performing an action, and healing him/herself. Each player can perform any of these actions whenever he/she decides to provided that he/she possess the corresponding resources.
- **Choice among different actions**. Players often have to choose between different actions in a given context. A key factor in which these choices differ is the number and nature of the possible actions among which the user have to decide. For example, consider that a player must choose between handling a valuable resource to obtain a benefit for the whole team or doing nothing. A trinomial of SYMLOG values is used to rate this action if he/she chooses to do nothing (values that imply a selfish or individualistic behavior) and completely different trinomial will be used if he/she chooses to handle the resource on behalf of the team.
- **Context/Condition**. In order to give accurate information about a player's behavior, the context in which a choice is made must be considered. For example, consider the following situation: A player must choose between discarding two cards or suffering a penalty that affects the whole group. Considering that running out of cards is a dangerous situation for a player, the information about how many cards the player has at the moment of making the choice is essential to determine

if the player is demonstrating a selfish, cautious, or reckless behavior. In order to be able to extract context information, the game state is recorded and analyzed. We considered the following set of variables about the game state: the position of the team in the main board, the position of the team on each activity line in the current stage/secondary board and the position of the team on the event stack. We also considered the following set of variables related to the state of each player: the position of the player in the main board and the number of each type of resources he possess. These variables enable the addition of question-like structures into the mapping model, to consider the context in which each action was performed. For example, a pair *HasMoreThanCards(2)* can be added into the context information area of the mapping model to check if the involved player has more than 2 cards at the moment of performing an action.

For each interaction in the game, all the factors described previously are considered to assign a value for different SYMLOG dimensions. Since each dimension has two opposite directions, when an action contributes to one direction this implies adding or subtracting a value in the corresponding dimension. For example, in the *Preparations* stage players can roll the dice or pick up a card from the stack. If the player chooses to roll the dice, this interaction affects the D and B direction of the U/D dimension and F/B dimension respectively (See Appendix A). This means that a value will be subtracted from both dimensions, since this behavior affects the negative direction of the dimensions involved. The P/N dimension is neutrally affected by this action.

Formally, we defined a function$f(A, O, C) \rightarrow V_{U/D}\, V_{P/N}\, V_{F/B}$, where A is the actions domain, O is the choices domain (including the *do-nothing* option, if it corresponds), C is conditions according to the state of the game (context), andV_* are direction affected for each SYMLOG dimensions. Following with the previous example, $f(\text{“}Preparation\text{”}; \text{”}RollDie\text{”}; \text{”}any\text{”}) \; = D\; B$

Appendices A, B and C show the dimensions considered in each situation for each type of action of the game investigated in this article. In order to create a mapping for other game, it is first necessary to check if it can be considered a collaborative game according to the requirements stated in Section 4.1. Then enumerate the different actions of each type (turn, optional and voting actions) that players can perform in the game. Finally, for each action, the different options that each player can select in each different context should be identified and mapped to one direction of each SYMLOG dimension.

It is important to remember that for each dimension it is possible to have a neutral value (absence of a value) or a direction value. Then, an action that affects the dimension U / D positively will take the value U, an action with an opposite effect will take the value D and no value will be given if the action does not affect this dimension.

5. Empirical evaluation

In this section we describe the empirical evaluation we performed to validate our approach. We first describe in Section 5.1 the recruitment procedure and the participants of the experiment. Then, in Section 5.2 we describe the procedure and the evaluation metric used. Finally, in Section 5.3 we analyze the results obtained.

5.1. Settings

We carried out an experimental evaluation with real users to test the proposed approach. We emailed invitations to 144 students from two different courses of the UNICEN University (Argentina) to participate in the experiment. We provided candidate participants with the URL hosting the developed game and suggested them to play more than one game session. Ninety-eight students manifestated their interest in participating and registered in the system (68%). The participants were aged between 20 and 25; 81% of them were male, while 19% were female.

For each game session, we divided registered participants in 20 groups with 4 or 5 players each, randomly selected. Participants played over 3 weeks an average of 13 game sessions, with standard deviation of 6 sessions. In order to evaluate the results, we only considered 77 players, which played 13 game sessions or more.

5.2. Procedure

The resulting dataset comprises data about 332 game sessions, with an average of 90 minutes each session. The shortest game sessions were around 32 minutes, while the longest sessions reached 118 minutes. Game sessions include information about which players participated, and all the actions (along with the context) performed by them. The dataset was processed with the approach presented in Section 4 and, as a result, a SYMLOG profile was obtained for each of the participants (referred to, from this point on, as the "game profile"). Remember that players were asked to fill an online version of the SYMLOG questionnaire at the moment of registering in the system (Section 4.1). In this way, we obtained the corresponding SYMLOG profiles based on the results of this questionnaire (referred to, from this point on, as the "questionnaire profile").

The evaluation metric we used to measure the distance between the game profile and the questionnaire profile was the cosine similarity between the corresponding SYMLOG trinomials (Eq. 1). In Eq. 1, QP denotes the questionnaire profile and GP the game profile, U/D denotes the Up/Down dimension, P/N the Positive/Negative dimension and F/B the Forward/Backward dimension.

$$\text{Cosine similarity (QP, AP)} = \frac{(QP_{U/D} * AP_{U/D} + QP_{P/N} * AP_{P/N} + QP_{F/B} * AP_{F/B})}{\sqrt{(QP_{U/D}^2 + QP_{P/N}^2 + QP_{F/B}^2)} * \sqrt{(AP_{U/D}^2 + AP_{P/N}^2 + AP_{F/B}^2)}} \quad (1)$$

The computation of the cosine similarity between two vectors produces as a result a real number between -1 and 1: a value of 1 represents two profiles that are identical (they have the same value for the three SYMLOG dimensions) and a result of -1 represents a maximum difference between the two profiles.

Since it is difficult to appreciate the performance of the approach only with the cosine similarity (considering the three dimensions together), we decided to analyze each SYMLOG dimension separately. Then, we also computed the absolute difference between the numbers obtained with the game for each SYMLOG dimension with respect to the numbers obtained with the questionnaire.

5.3. Results

We computed the cosine similarity for each of the 77 users who played at least 13 game sessions and averaged the results in order to give a general measurement of the similarities between the game profile and the questionnaire profile. As a result, we obtained an average cosine similarity of 0.4996. If we consider that if both profiles were the same, the cosine similarity would be 1 and for an opposite profile, the cosine similarity would be -1, we can normalize this value in the range [0,1] to obtain an average similarity of 0.7498.

Table 2 shows the average difference between the game profile and the questionnaire profile for each SYMLOG dimension individually, along with the standard deviation. Notice that in this case, the closer to 0 represents the better performance since a value of 0 corresponds to the same value for the given dimension and a value of 1 represents the maximum difference between both profiles. We can observe that our approach was able to accurately capture the players' collaborative profile for the Up/Down and Positive/Negative dimensions. On the other hand, the performance was lower for the Forward/Backward dimension.

Table 2. Average difference between the game profile and the questionnaire profile for each SYMLOG dimension

Dimension	Average difference	Standard deviation
Up/Down	0,08163112	0,06741177
Positive/Negative	0,02649075	0,09720355
Forward/Backward	0,2318968	0,0976197

Since SYMLOG profiles are a characteristic of the individual that is dependent on the context (in the sense that both teammates and the game elements might influence his/her behavior), we analyzed how the difference among the game and the questionnaire profiles evolved across game sessions. Figure 3 shows the average difference between the game and the questionnaire profiles after each game session (represented in the X-axis) for each SYMLOG dimension.

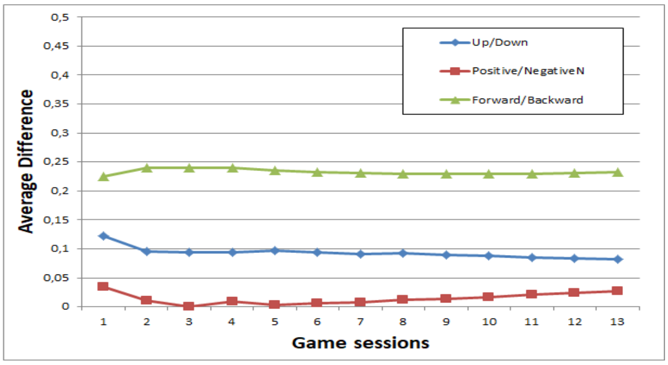

Fig. 3. Absolute distance between the profiles generated by the game and the survey.

Figure 4 contrast the profiles generated in each game session for 5 users randomly selected from the 77 participants of the experiment who played at least 13 game sessions. Each figure shows the profile generated by the questionnaire, the partial profile computed for each game session, and the cumulative profile of all previous sessions. Notice that the questionnaire profile remains constant since the questionnaire was only filled at the beginning of the experiment. The X axis represents the game session number and the Y axis represents the profile value for each dimension, normalized in the range [0,1], being 0.5 the neutral value for each dimension. We can observe that, although the partial profiles have several peaks, the cumulative profile tends to stabilize as the individuals play more game sessions. Furthermore, the cumulative profiles tend to converge to the questionnaire profiles for P/N and U/D dimensions. For F/B dimension, the difference between the game and questionnaire profiles is more evident for most cases.

The peaks observed for the partial profiles shows the importance of playing several times for a correct modeling of the players' profiles. We can observe an extreme behavior for *User B* in the U/D dimension in which he/she obtained a value of 1 in session 7 and a value of 0 in session 8. In session 7, User B exhibited a completely dominant role (U) which is paired with an unfriendly behavior (N) expressed in the P/N dimension. However, this behavior is not recurrent in this user, since there are not such peaks in the partial profiles corresponding to other game sessions, except for game session 8 in which this user exhibited a social behavior (as can be seen in F/B dimension) moving away from goals (B) and expressing a submissive behavior (D). Similarly, *User D* in session 9 exhibited an extreme submissive (D) and opposed to goals (B) behavior.

Another interesting peak to analyze is that which occurred for User E in session 5 in which he/she exhibited a negative behavior for all dimensions. In this case, the user showed a totally submissive, unfriendly and opposed to goals behavior. Although in this particular game session the user did not exhibited a behavior according to his/her questionnaire profile, in the next sessions the accumulative profile converge to the questionnaire profile showing the importance of playing several sessions to correctly capturing the real collaborative profile of the user.

To conclude, we believe that the variations of the partial profiles can be attributed to the fact that teammates influence the behavior of individuals. However, after several game sessions in which individuals interact with different groups, we can observe that their behavior tends to converge with the values obtained with the questionnaire.

Comment [1]: Para no

Comment [2]: In the F
observe that for user A, i
dimension, his accumula
behavior moves away fro
detected by the question
Similarly, this behavior c
in the F / B dimension. W
dimension remains simila
data we can interpret tha
assists submissive but a
confidence his behavior
more dominant. Similarly
begins by showing a task
profile and then their beh
more socio-emotional. A
personality, he shows hi
constantly positive. The
sessions 7 and 8 were m
and had a prominent par
the profile is triggered in
dimensions. Particularly
dimension in session 7 h
leadership and in sessio
completely opposite star
decisions also affect the
dimension, being extrem
when I take a dominant p
more positive when it wa
submissive. Finally, in th
dimension, it can be see
session 8 his posture wa
emotional than task orie
be observe that for user
7 and 9 were of short du
the proximity to the neutr
(approximately 0.5) in th
dimensions. While the us
average cumulative beha
that which could be calcu
questionnaire, triggers in
that the participant did no
end game sessions, des
finished these with a win
User (d) in session 4 the
neutrality in the 3 dimens
evidences the abrupt ter

Comment [3]: juan tos
"games": 15,
"won": 5,
"points": 250,
"chats": 553,
"survives": 5

Fig.4. Partial profiles generated in each game session contrasted with the questionnaire profile and the cumulative profile (game profile)

In order to give an integrated view, with the three SYMLOG dimensions, of the difference between the game profile and the questionnaire profile, we plotted two extreme examples taken from our dataset in a field diagram as that presented in Figure 1. The visualization of both profiles on the same plot enables an intuitive comparison between them. Figure 5 shows the final field diagram as those that players can observe for their own profiles in the developed game.

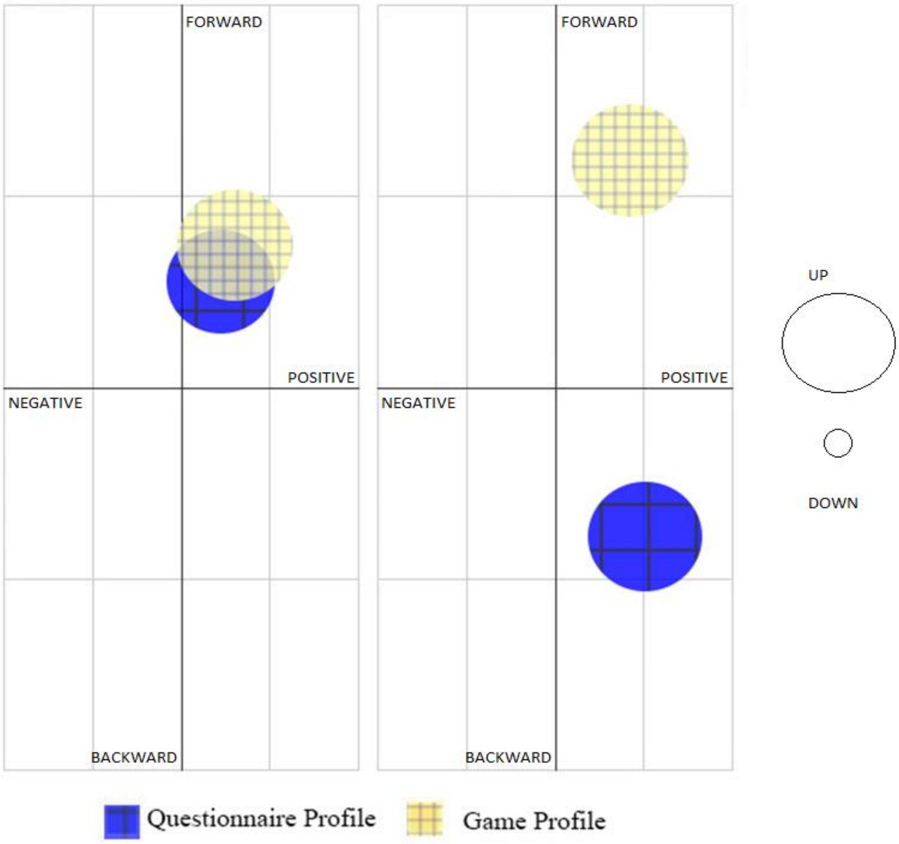

Fig. 5. Field diagrams for two different players plotting the game profile and the questionnaire profile.

The first diagram (left) shows the player for which the distance of the two profiles is minimal. We can observe that the center of the circles is close and that the diameter of the circle is very similar for this user. In contrast, the second diagram (right) shows the player with the longer distance between the game profile and the questionnaire profile. In order to analyze this difference, we compared the answers given in the questionnaire with his/her interactions in the game. The answers of this player to the SYMLOG questionnaire demonstrated that he/she tend to not participate actively in the decisions when interaction in a group. According to Bales (1983), the location of the circle corresponding to the questionnaire profile on the backwards side of the F/B dimension mean that he/she can be seen as unconcerned with the task at hand. However, by analyzing the behavior of this player during the game, we observed that he/she generally encouraged the teams in which he/she participated to move towards the goal with a challenging and courageous attitude to overcome obstacles. By analyzing the chats of the game and the choices made by this player, we could see that he/she demonstrated an active participation in the decisions of the group, opposed to his/her self-perception. For this reason, the game profile located this player in the forward side of the F/B dimension. Regarding the other two dimensions defined by SYMLOG, both profiles resulted similar.

6. Implications

The main idea behind our approach is to use the proposed game as an alternative to completing the SYMLOG questionnaire. Although the SYMLOG profile of an individual could be different in other contexts, we believe that our approach is a good starting point to profile the collaborative behavior of individuals that might not be able to fill the questionnaire (for example children). In the experiments section we showed how the partial profiles differ in different game sessions of the same individuals, concluding that teammates might influence the individual behavior. However, after several game sessions, we observed that the cumulative profile (i.e. the game profile) tended to converge with the values obtained with the questionnaire.

Our work has potential implications for organizations and for the classroom since it provides an engaging tool for measuring the collaborative behavior enabling the identification of the skills that must be trained, reinforced or avoided by the members of each group. In this direction, considering the *Most Effective Profile* shown in Figure 1, the field diagrams presented by the game for each user can give useful insights:

- if the game profile is extremely to the right (P) of the field diagram, the player should learn to pose his/her point of view and stand firm with his/her decisions, although this behavior might lead to occasional disagreements with the rest of the group. Otherwise, if the game profile is on the left (N) of the field diagram (specially with negative values), the player must try to reach an agreement with the group decisions in more opportunities;
- if the game profile is represented by a big circle (U), the player should be more polite in the communication of his/her decisions and should try to avoid confronting others. On the contrary, if the game profile is represented by a small circle (D), the player needs to increase his/her confidence on his/her actions and try to participate in the group decisions by posing his/her point of view;
- if the game profile on the top of the field diagram (F), the player should prioritize his/her responsibilities with respect to the common goal of the group. However, if the game profile is on the bottom of the field diagram (B) the player should pay attention to the group's common goal and be less obsessed with his individual interests.

With these guidelines, each player can be able to perform a self-evaluation and try to improve his/her collaborative behavior by him/herself. On the other hand, team leaders or teachers, can check the evolution of the collaborative profiles of the subjects and train them in the skills they need to develop to improve their collaborative behavior. To help users towards this aim, the developed tool gives recommendations regarding each profile following the above-mentioned guidelines.

7. Conclusion

In this work, we introduced an approach to automatically and unobtrusively build SYMLOG profiles with an online multiplayer collaborative game. Our approach involves the use of a specific board game, that was carefully selected and digitalized, and a well-known theory for measuring group dynamics. We developed the platform needed to allow users to easily play this game and gather all the relevant data regarding the player's' behavior. We also proposed a model to map actions on this game to SYMLOG profiles.

An experimental evaluation was carried out with a group of 98 players. Experiments confirmed our hypothesis that stated that it is possible to automatically learn SYMLOG profiles from the observation of their actions in a collaborative game, since the profiles built with our approach resulted similar to the profiles obtained by the SYMLOG questionnaire.

One of the main advantages of our approach is that when playing the game, users demonstrate their behavior in a real scenario in contrast to the hypothetical scenario posed in the questionnaire. We found that participants for which the questionnaire and the game profiles resulted different in any dimension his behavior was more representative of the profile captured with the game than of the self-perception profile captured with the questionnaire. Since our approach involves a non-intrusive way to learn the player’s collaborative profiles, we believe that players can exhibit their real behavior without feeling that they are being observed.

One of the limitations of our approach is that the quality of the model can vary depending on the amount of context information gathered for each interaction, which depended on each specific game session. Since different game sessions might have fewer contexts or less context quality than others, we suggest that players should play the game more than four times so that his/her real collaborative profile can be demonstrated by his/her interactions in the game.

As a future work, we plan to enhance the development game with an intelligent analysis of the text interactions in the chat window. We believe that the content of the messages sent by a user can positively improve the generated profile. Furthermore, we are currently evaluating the possibilities of reducing the number of stages of the game to shorten the game duration without affecting the quality of the generated profiles. Additionally, we plan to work with other collaborative platforms, such as Google Docs or Github, to apply our approach in order to validate if the resulting profiles are correlated independently from the platform used.

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Appendix A

Table 1. Turn Action

Action	Choice	Condition	Affected SYMLOG dimensions
Preparations	Roll Die	*any*	DB
	other	*any*	F
Fellowship	Force Discard	*any*	DPF
	other	*any*	UNB
Speak Friend	Common Discard	*any*	
	other	*any*	UNB
Recovery	DealHobbitCards	HasLessThanCards (3)	UF
		HasMoreThanCards (6)	UNB
		other	U
	Move Player	IsCloseToSauron	F
		IsFurther HasLessThanCards (3)	NB
		IsFurther	UNB
		other	UF
	other	HasEqualOrMoreTokens (shield, 3)	DNB
		other	P
GalardielTest	Force Discard	HasLessThanCards (4)	DPB
		HasMoreThanCards (10)	PF
		other	D
	other	HasLessThanCards (4)	F
		HasMoreThanCards (10)	UNB
		other	U

OrthancFire	Force Discard	*any*	DPF
	other	HasMoreThanCards (10)	UNB
		other	N
DeadFaces	Kill Player	HasMoreThanCards (7)	
		HasEqualOrMoreTokens (shield, 3)	DNB
		other	DN
	other	*any*	F
NazgulRing	Force Discard	*any*	PF
	other	HasMoreThanCards (10)	UNB
		oother	UN
ShelobAppe ar	Roll Die	*any*	DN
	other	*any*	UNB
SamSaveFro do	Change Token	HasEqualOrMoreTokens (shield, 6)	UF
		other	P
	other	HasEqualOrLessTokens (shield, 3)	UF
		other	DB
PelennorFiel ds	Roll Die	HasEqualOrMoreTokens (life, 2)	DNB
		other	
	other	*any*	PF
SauronMout h	Roll Die	HasEqualOrMoreTokens (sun, 2)	DNB
		other	
	other	*any*	PF
CardsPhase	Next Phase	*any*	P
	other	HasFewerCards	UNF
		IsCloserToSauron	UNF

other	UNB

Appendix B

Table 2. Optional Actions

Actions	Choice	Condition	Value
PlayGandalfCard	Prevision	HasEqualOrLessTokens (shield, 6)	DPB
		other	PF
	Guía	HasEqualOrLessTokens (shield, 6)	DPB
		other	PF
	Sanación	HasEqualOrLessTokens (shield, 6)	PF
		HasEqualOrLessTokens (shield, 6)	UB
		IsCloserToSauron	UP
		other	
	Persistencia	HasEqualOrLessTokens (shield, 6) HasLessThanCards (5)	F
		HasEqualOrLessTokens (shield, 6)	P
		HasLessThanCards (5)	UPF
		other	UB
	Magia	HasEqualOrLessTokens (shield, 6)	PD
		other	PF
PlayCard	Miruvor	*any*	PD
	Staff	*any*	P
	Athelas	*any*	P
	Elessar	IsCloserToSauron	UPF
		other	U
	Mithril	*any*	U
	Phial	*any*	P

Belt	*any*	U
Lembas	HasLessThanCards (4)	UF
	any	NB
Dagger	IsCloserToSauron	UN
	other	UNB
Devil	*any*	UNB

Appendix C

Table 3. Voting Actions

Actions	Choice	Condition	Value
PlayerDealCards (players)	forward_backward	agree	F
		disagree	B
	up_down	self-agree HasFewerCards	U
		self-agree	U
		self-disagree HasFewerCards	DB
		self-disagree	P
		others agree HasFewerCards	DP
		others agree	PF
		others disagree	
CommonDiscard (discards, alias)	forward_backward	agree	F
		disagree	B
	up_down	self-agree HasFewerCards	DB
		self-agree	PFD

		self-disagree HasFewerCards	UF
		self-disagree	UN
		others agree	F
		others disagree	
Nazgul Appears (alias)	forward_backward	agree	F
		disagree	B
	up_down	self-agree	PD
		self-disagree	U
		others agree	UN
		others disagree	
FlyFools (alias)	forward_backward	agree	F
		disagree	B
	up_down	self-agree IsCloserThan (3)	PDB
		self-agree IsFurtherThan (6)	PFD
		self-agree	PFD
		self-disagree IsCloserThan (3)	PDB

		self-disagree IsFurtherThan (6)	PFD
		self-disagree	PFD
Wormtongue (alias)	forward_backward	agree	F
		disagree	B
	up_down	self-agree	DN
		self-disagree	U
		others agree	UN
		others disagree	
ForbiddenPool (alias)	forward_backward	agree	F
		disagree	B
	up_down	self-agree HasEqualOrLessTokens (shield, 6)	PDB
		self-agree HasEqualOrMoreTokens (shield, 10)	PF
		self-agree	PD
		self-disagree HasEqualOrLessTokens (shield, 6)	PDB
		self-disagree HasEqualOrMoreTokens (shield, 10)	PF
		self-disagree	PD
		other agree	UN
		other disagree	P

LordAttack (alias)	forward_backward	agree	F
		disagree	B
	up_down	self-agree HasMoreThaCards (8)	PF
		self-agree HasLessThanCards (shield, 5)	DP
		self-agree	DP
		self-disagree HasMoreThaCards (8)	UNB
		self-disagree HasLessThanCards (shield, 5)	F
		self-disagree	
		others agree	U
		others disagree	
SauronWill (alias)	forward_backward	agree	F
		disagree	B
	up_down	self-agree IsCloserThan (3)	DPB
		self-agree IsFurtherThan (5)	DPF
		self-agree	P
		self-disagree IsCloserThan (3)	UF
		self-disagree IsFurtherThan (5)	UNB
		self-disagree	

	others agree	U
	others disagree	