

Automatic Mental Health Assistant: Monitoring and Measuring Nonverbal Behavior of the Crew During Long-Term Missions

Natalia Voynarovskaya

Eindhoven University of Technology
User System Interaction
n.voynarovskaya@tue.nl

Roman Gorbunov

Eindhoven University of Technology
Designed Intelligence Group
r.gorbunov@tue.nl

Emilia Barakova

Eindhoven University of Technology
Designed Intelligence Group
e.i.barakova@tue.nl

Matthias Rauterberg

Eindhoven University of Technology
Designed Intelligence Group
g.w.m.rauterberg@tue.nl

ABSTRACT

This paper presents a method for monitoring the mental state of small isolated crews during long-term missions (such as space mission, polar expeditions, submarine crews, meteorological stations, and etc.) The research is done as a part of Automatic Mental Health Assistant (AMHA) project which aims to develop set of techniques for automatic measuring of intra- and inter- personal states in working groups. The method is focused on those aspects of psychological and sociological states that are crucial for the performance of the crew. In particular, we focus on measuring of emotional stress, initial signs of conflicts, trust, and ability to collaborate. The present research is performed in collaboration with MARS-500 experiment in which a small group of people is isolated for a long period of time. The MARS-500 experiment, in this way, provides a unique platform for study of human-human interaction. The confinement study will imitate all key peculiarities expected to be present during future missions to Mars (i.e. ultra long duration flight, need for autonomy, complicated communication with a digital communication center due to signal delay, and limited stock of expendables). The developed method is also currently tested by usage of a web-based platform.

Author Keywords

Social network analysis, nonverbal communication, emotions, long-term missions, evolutionary game theory,

colored trails.

INTRODUCTION

Long-term missions usually are performed by small group of people, and characterized by extreme physical and psychological parameters. Specific conditions like special confinement, small group living, extreme social isolation, risk, working together in close proximity [2], could have a crucial negative influence on the mental state of crew members as well as the social atmosphere in the whole crew. The interpersonal issues, such as crew tension, cohesion, leadership, language, cultural factors [1], could cause personal conflicts which could affect the performance of the mission. According to Russian psychologists [3], the main objectives of psychological countermeasures during space flight, are (1) physiological reconstruction of the informational environment, (2) correction of psycho-emotional area of astronauts, and (3) prevention of insufficiency in social contacts. For measuring, prediction and prevention of the above mentioned problems it is crucial to have methods for automatic monitoring of psychological and social states in the group. The psychological states of the crew members as well as different aspects of interpersonal relations have been assessed using different approaches. In the current study we combine three approaches: strategic multiplayer game, [8, 11], techniques for automatic monitoring of nonverbal behavior [17,18,21,22,23], and self assessment based on questionnaires. In this way we are aiming to overcome limitation of every component and develop a self consistent and comprehensive technique for monitoring intra- and inter-personal state of the crew members.

RELATEDWORK

The first concept of the AMHA project has been done within Mars-500 experiment for 105 days isolation [4].

In 2004 the Institute for Biomedical Problems (IBMP) in Moscow and the European Space Agency have started to

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post of servers or redistribute to lists requires prior specific permission and/or a fee.

plan a full-scale ground based simulation of a manned mission to Mars. Such a full scale mission requires between 520 to 700 days of isolation. Referring to the lower end of this time frame the initiative was named Mars-500.

A crew of six candidates (four Russians and two from EU countries) are sealed insight the facilities of the Institute for Biomedical Problems in Moscow. An initial 105-day isolation period took a place in spring of 2009. The present concept is going to be tested in the full 520-day study, which is planned to launch in the first quarter of 2010.

Game Theory and Colored Trails

In this project, we explore the use of strategic multi-player games to alleviate stress, and more importantly as an unobtrusive tool to monitor the mental capacity of astronauts as well as the development of different social interaction patterns within the crew. We are primarily interested in games that feature the following properties:

- Simple enough for analysis
- Rich enough to reflect features of real life interactions
- Grounded in a situated task domain
- Strategic (i.e. partial information that promotes reasoning)
- Suited to measure social factors such as fairness

We are also interesting to produce data, which directly involve interpersonal relation and, as a consequence, can be interesting to monitoring social atmosphere in the crew.

As such a tool, we used a three-player negotiation variation [25] of the Colored Trails framework developed at Harvard University [24]. The Colored Trails game is played on a board of colored squares. One square is designed as a "goal square". Each player has a piece on the board and possesses a set of chips in colors chosen from the same palette as the squares of the board. To move own piece into an adjacent square a player must turn in a chip of the same color as the square. Chips can be exchanged by the players if a mutual agreement is reached. The goal of the game is to move own piece as close to the goal square as possible using as less chips as possible. Distance to the goal is more important than number of chips left after the move.

METHOD

Design of the presented monitoring system is based on our previous analysis of the data obtained in the MARS-105 experiment. In particular we analyzed behavior of Responders. Situation, in which a responder needed to make a decision, was described by two numbers: how the Responder can improve his/her payoff by accepting the first offer and how he/she can improve his payoff by accepting the second offer. This description of the situation is a simplification because other factors can influence the decision of the Responder (for example what other player will get as a result of his/her decision or how good are the available offers in comparison with the offers which could

be proposed). However, the two selected parameters are the

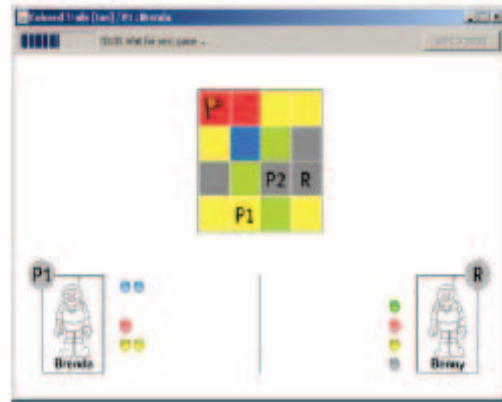


Figure 1. Colored Trails Game

only factors, which are determining behavior of the Responder and showing if the player’s behavior is totally rational. So, the mentioned two parameters can be used to check how rational the behavior of Responder is. This check is important because any deviation from the rational behavior can potentially be an indication of psychological preferences or other interpersonal relations.

On the Figure 2 is shown the behavior of one of the Responders. The x- and y-axis corresponds to the improvement of the payoff which can be achieved by accepting the first and second offers, respectively. So, generally speaking, every point in the plot represents a particular situation in which the given Responder needed to make a choice. The color of the point indicates the choice which was made. The red/blue colors mean that the first/second offer was accepted. The green color means that the both offers were rejected.

The space on the graph is divided into three different regions. If a responder is totally rational, every region should only contain points of one corresponding color. For examples, if both offers worsen the payoff of the responder (the left bottom region) than both offers should be rejected

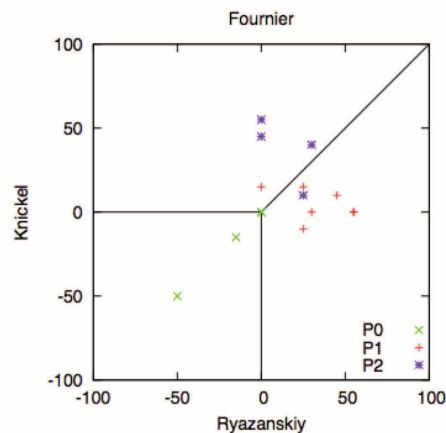


Figure 2. Dependence of the behavior of one Responder on the accepted offer.

(green points). The right-bottom region means that the first offer is better than the second one and it improves the payoff of the responder (so, in this case the first offer should be accepted (red points)). In the third region (left-top) the second offer should be accepted (blue points).

Generalization of the Colored Trails

For 520 days isolations study, we propose a generalization of the Colored Trails game. In the new version of the game every user plays as Proposer. Moreover, in contrast to the previous version of the game, Proposers are free to choose a player (Responder) whom he/she wants to offer a chips exchange. As a consequence of these modifications, two or three players will play the Responder role in the second stage of the game. The introduced modifications provide several advantages.

First, we increased number of Proposer per game (from 2 to 3) and, as a consequence, we get more data about the behavior of Proposers.

Second, we increased the number of Responders (from 1 to 2 or 3). This way more information about behavior of Responders can be collected.

Third, we increased the variety of situations in which Responders can be. In particular, Responders have to choose from different number of offers coming from Proposers which are in different situations.

Forth, based on the analysis of the previous experiment, we added a phase at the game, which is aimed to assess irrational preferences of the players. At this stage, when each player is choosing a partner for a current game, player's behavior can not be based on rational thinking about state of the game, and provide explicit unconscious choice of the partner.

In addition to the previous experiment we combine the usage of the negotiation game with direct monitoring of the nonverbal behavior of the subjects. In that way we want to study if our conclusions about user's persistence of the game and other player can be confirmed by the other kindsof measurements. In particular, the monitoring techniques can be used to detect if players are satisfied or not with offers from other players as well as decisions made by the Responders.

Design Concept

To build the AMHA concept model, first of all, we defined the parameters, which are crucial for successful communication and collaboration, such as stress level, pleasure, trust, dominance, and etc. Furthermore, we defined a personal mental state and interpersonal relationships as two main components of the crew mental health. The combination of different techniques is required to assess different aspects of the psychosocial states as well as to perform cross validation and correct interpretation of the collected data (see Figure 3).

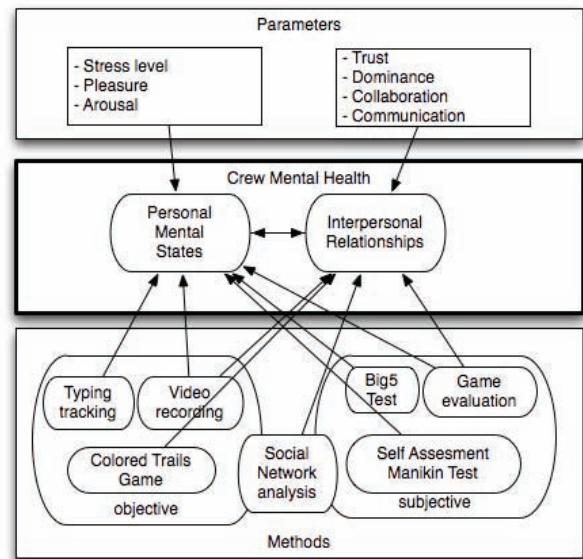


Figure 3. AMHA concept model.

To assess the emotional parameters during the game, players will be asked to fill in the questionnaires.

Usage of questionnaires for a self assessment is important component of our design, since crew members can provide explicit information about their psychological states and interpersonal relations in the crew. This information is important for interpretation of the game results in terms of perception of psychosocial state of the crew.

Self Assessment Techniques

Self assessment is an important component of mental health assistant since subjects can explicitly provide needed information about intra- and inter- personal states.

Big 5 Test

One of the intentions of our experiment is to find a relation between observed dynamics of the interpersonal relations with psychological parameters of the crew members. Such a relation could help us to generalize the behavior observed in particular crew and to predict, in this way, relations in groups consisting of members of similar psychological types.

In this sense, at the baseline of the experiment, we want to get data, which could give us the psychological characteristics of participants about personality and collaboration patterns at the same time. This data we can use as a reference point in the future data analysis. For our purpose we are using the Big 5 Test [10,12].

The Big Five model is considered to be one of the most comprehensive, empirical, data-driven research findings in the history of personality psychology. Over three or four decades of research, these five broad factors were gradually discovered and defined by several independent sets of researchers.

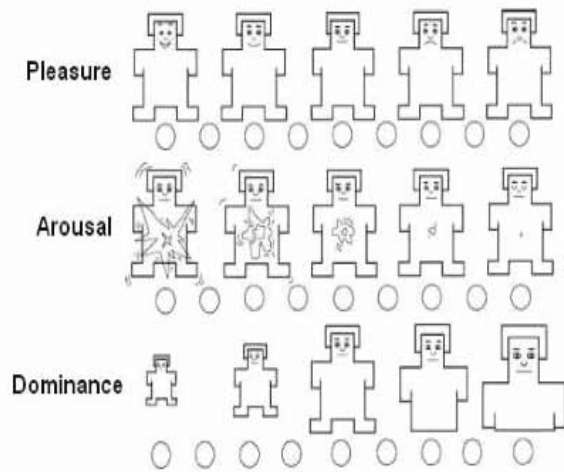


Figure 4. SAM test.

Self Assessment Manikin (SAM) Test

To assess emotional state of the participants, we are using the Self-Assessment Manikin test [13,14]. It offers the ability to avoid the verbal expression of the emotion assessment, so it establishes a quick and easy to use experimental procedure.

The test assesses the follow emotional states: “Pleasure”, “Arousal” and “Dominance”. In our study we used the initial verbal expressions of the three dimensions.

Usage of this technique has few advantages. The test is well established, it’s aimed for the main and basic parameters, but the results are full enough for analysis. And it’s simple, quick and intuitive to perform, which is crucial for our design.

Measuring Nonverbal Behavior

Automatic monitoring of face expression, voice intonation and body movements were proven to be useful techniques for monitoring of emotional states of subjects. These techniques are important since humans naturally express their emotions through nonverbal behavior.

In our study we use records of facial expressions during the people are playing the Color Trails Game. Facial expressions give important clues about emotions. In contrast to self assessment techniques, the tracking of nonverbal behavior provides information about emotions and psychological state unconsciously. It would allow us to get more objective data compared to results of questionnaires.

Using the software for analysis video (like Visual Recording by University of Amsterdam), we would be able to put in numbers 6 main emotions [9].

Social Network Analysis

To describe the relation between participants and analyze how the relations are developing through the time, we use Social Network Analysis (SNA). SNA defines networks as

sets of ties linking several individuals. Ties or contacts may be of different kinds, formal or informal, frequent or infrequent, affect-laden or purely utilitarian. Network analysts use the terms "transactional content" or "tie type" to identify the type of exchange or relationship that takes place between actors in a network [15]. SNA approaches allow not only to draw a ‘map of ties’ between structures/institutions/ societies as macro-level of social reality, but, in addition, to track changes that occur with these ‘actors’ during social transformations in the contexts of interconnections at the micro-level.

DISCUSSION

In connection with the Mission Execution Crew Assistant (MECA) by TNO [19, 20], we have a unique possibility to test our design within MARS- 500 experiment. MARS-500 provides a unique test platform, because of its setting in which a small crew is isolated for a long duration to simulate a manned Mars mission. In this setting, more prolonged or repeated usage of AMHA can be tested. In the MARS-500 program, we will select a small set of core elements of AMHA that need this type of prolonged evaluation: a diagnostic method to measure psychosocial crew status and a feedback mechanism. The objective of this evaluation is to improve the requirements baseline and its design rationale for these elements, and to refine the corresponding models and methods.

To get quantitative data, we are running an additional web-based study. For this purpose the web-site with Colored Trails Game has been developed.

The research questions for this experiment, apart to get quantitative data, are:

- how the CT game can develop the patterns of existing relationships between people;
- how the CT game can create the relationships between people;
- how the CT game can monitor the behavior.

In these settings we are planning:

- 5-6 groups (by 3 person each) people who know each other
- 5-6 groups (by 3 person each) people who don’t know each other
- About 15-20 groups of three people, which are know each other well and/or working together.
- Three sessions per week.
- The duration of the experiment is 15-18 sessions (5-6 weeks).

By the end of the experimental part of the project, we would be able to do data analysis. Two different experimental settings provide an opportunity to cross a validation and answer the question of transferability of results obtained with a single experiment with fixed constraints.

REFERENCES

1. Kanas, N., Salnitsky, V., Grund, E., Gushin, V. Social and cultural issues during Shuttle/Mir space missions. *Acta Astronautica*, 47, 2-9 (2000), 647-655.
2. Manzey, D. Human missions to Mars: new psychological challenges and research issues. *Acta Astronautica*, 55(2004), 781-890.
3. Gushin, V. Psychological countermeasures during space missions: russian experience. *Journal of Gravitational Physiology*, 9, 1 (2002), 311-312.
4. Hennes, D., Tuyls, K., Neerincx, M.A., Rauterberg, G.W.M. Micro-Scale Social Network Analysis for Ultra-Long Space Flights. *IJCAI-09/SMC-IT-09/IWPSS-09 Workshop on Artificial Intelligence in Space*, 2009
5. Hennes, D., Tuyls, K., Rauterberg, G.W.M. State-Coupled Replicator Dynamics. 8th International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2009), 789-796.
6. Hennes, D., Tuyls, K., Rauterberg, G.W.M. Formalizing Multi-state Learning Dynamics. *IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (IAT 2008)* vol. 2, 266-272.
7. Rauterberg, G.W.M., Neerincx, M.A., Tuyls, K., Loop, J. Entertainment computing in the Orbit. *New Frontiers for Entertainment Computing*, 279 (2008), 59-70.
8. Gaal, Y., Grosz, B.J. Colored Trails: A Formalism for Investigating Decision-making in Strategic Environments, 2005.
9. Valenti, R., Sebe, N., Gever, T. Facial Expression Recognition: a Fully integrated approach, 2007.
10. John, O.P., Srivastava, S.: The Big-Five Trait Taxonomy: History, Measurement, and Theoretical Perspectives, 2005.
11. Camerer, C.F. Behavioral Game Theory: Thinking, Learning, and Teaching, 2001.
12. Harvey, R.J., Murry, W.D., Markham S.E. A "Big Five" Scoring System for the Myers-Briggs Type Indicator, 1995.
13. Bradley, M.M., Lang, P.J. Measuring Emotions: the Self-Assessment Manikin and the Semantic Differential. *J. Behav. Ther. and Exp. Psychiat.*, 25, 1 (1994), 49-59.
14. Tsonos, D., Kouroupetroglou, G. A Methodology for the Extraction of Reader's Emotional State Triggered from Text Typography. *Tools in Artificial Intelligence*(2008), 139-154,
15. Nelson, E.. The Strength of Strong Ties: Social Networks and Intergroup Conflict in Organizations. *The Academy of Management Journal*, 32, 2 (1989), 377-401.
16. Busso, C., Deng, Z., Yildirim, S., Bulut, M., Lee, C.M., Kazemzadeh, A., Lee, S., Neumann, U., Narayanan, S. Analysis of Emotion Recognition using Facial Expressions, Speech and Multimodal Information, 2004
17. Mase K. Recognition of facial expression from optical flow. *IEICE Transc.*, E. 74, 10 (1991), 3474-3483.
18. Yacoob, Y., Davis, L. Computing spatio-temporal representations of human faces. *Computer Vision and Pattern Recognition. Proceedings CVPR '94, IEEE Computer Society Conference* (1994), 70 -75.
19. Neerincx, M.A., Lindenberg, J., Smets, N. The Mission Execution Crew Assistant: Improving Human-Machine Team Resilience for Long Duration Missions, 1998.
20. Breebaart, L., Bos, A., Grant, T., Soler, A.O., Neerincx, M.A., Lindenberg, J., Smets, N., Brauer, U., Wolff, M. The MECA Project — Ontology-based Data Portability for Space Mission Operations, 2008.
21. Barakova, E., Lourens, T. Expressing and interpreting emotional movements in social games with robots. *Personal and Ubiquitous Computing*, 2010.
22. Lourens, T., Barakova, E. Retrieving Emotion from Motion Analysis: In a Real Time Parallel Framework for Robots. In C.S. Leung, M. Lee, and J.H. Chan (Eds.): *ICONIP 2009, Part II, LNCS 5864*, 430-438.
23. Lourens, T., Barakova, E. My Sparring Partner is a Humanoid Robot -A parallel framework for improving social skills by imitation. In J. R. Alvarez, editor, *IWINAC 2009*, number 5602 in *Lecture Notes in Computer Science*, 344-352.
24. Gal, Y., Grosz, B. J., Kraus, S., Pfeffer, A., Shieber, S. Colored trails: a formalism for investigating decision-making in strategic environments. In *Proc. of the IJCAI Workshop on Reasoning, Representation, and Learning in Computer Games*, 2005.
25. Ficici, S., Pfeffer, A. Modeling how humans reason about others with partial information, 2008.