Physiological Data Monitoring of Members of Air Forces During Training on Simulators

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Abstract

Many complex situations can be induced to the members of air forces during training on simulators, which may result in mentally vigorous situations or even overload. The aim of the paper is to describe the current state and our contribution to development of systems for measurement of the physiological data of basic member of air force including mission commander, pilots, air traffic controllers and ground support staff. The reason for physiological data monitoring is to test the possibility of usage them to estimate the physical and psychological state of the team members. The base for the design of physiological data monitoring was the FlexiGuar system, originally developed at the FBMI CTU. The core of simulators for training of military personnel in aviation was Lockheed Martin's Prepar3D simulation software. Two airplane cockpits were used as simulators for training of two pilots, air traffic control simulator, i.e. a control tower simulator, and an airport ground station for the preparation of aviation ground staff. The proposed systems are used for simultaneous measurement of the working performance and physiological data of members of the four-member team during their training. The physiological data, heart rate, body temperature, movement activity and perspiration intensity, are transferred to the commander visualization unit for further evaluation. Designed systems and methods could help to monitor, on the base of physiological data and data from simulators, the stress load of team members.

Keywords

Physiological data • Stress load • Air force
Training • Simulators

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1 Introduction

Intensive research is currently underway on the development of for monitoring health state of employees in aviation [1], including in military aviation [2]. The objective of health state measurement is to use this information on employee health state to increase safety, i.e. to supplement the information used in the monitoring or sensor subsystem of the control system, which will be able to intervene to control [3, 4]. However, in the development of prospective systems, pilot health state monitoring is only assumed. The health state monitoring of other aviation personnel, such as air traffic controllers (ATC) and ground support staff, is given

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little attention. Also, the monitoring of the health status of all key members in aviation is nowhere suggested or presented.

The aim of this article is to describe the current state and our contribution to development of systems for measurement of the physiological data of basic member of air force including mission commander, pilots, air traffic controllers and ground support staff. The reason for physiological data monitoring is to test the possibility of usage them to estimate the physical and psychological state and eventually for identification of dangerous situations in the staffing of the military mission.

2 Methods

Based on the above mentioned requirements, methods of direct measurement of the physical and psychological state of the staff members can be designed. Methods may provide both behavioural and cognitive/emotional physiological measures to assess the performance of members and unit as a whole [5]. All these methods assume a direct measurement of the physiological indicators of the health state of staff.

2.1 Participants

Twenty-eight soldiers (aged 21.1 (SD 2.2)) were recruited for measurement. Soldiers were cadets of University of Defence which is the only military institution of higher education of the Czech Armed Forces. Students were future members of air forces preparing for the profession of pilot and air traffic controllers. However, they had only minimal or zero experience with aircraft piloting. Cadets were subjected to diagnostic evaluation focused on detailed disease history, a neurologic examination, and routine laboratory testing. The study was performed in accordance with the Helsinki Declaration. The study protocol was approved by the local Ethics Committee of the Faculty of Biomedical Engineering of the Czech Technical University (CTU) in Prague. The subjects were measured on same days.

2.2 Measurement Equipment

Measurement systems can be divided into two groups: simulators for training and system for monitoring physiological data.

The base for the design of physiological data monitoring was the FlexiGuar system, originally developed at the Faculty of Biomedical Engineering, Czech Technical University in Prague [6]. The FlexiGuard system is modular biotelemetric system for real-time monitoring of special military units. However, this system and its previous use assumed the measurement of individuals of a homogeneous group, i.e. individuals performing an identical task with the same difficulty during a mission. In our case, the application assumes measurement of a non-homogeneous group, i.e. parallel monitoring of each member of the special team individually. The systems consists of a set of sensors for monitoring body temperature, heart rate, acceleration and humidity [6, 7]. The modular sensing units records the measured data and send them wireless to the visualization unit. All data are transmitted wirelessly to visualisation unit. The limit values of the measured physiological data for each subject can be individually set in accordance with the expected values of a particular subject undergoing a specific task within the mission. These values are determined and set by the expert before the measurement. The physiological data (heart rate, body temperature, movement activity and perspiration intensity) and their comparison with the limit values are transferred to the commander visualization unit for further evaluation.

Simulators for training can be divided into three groups: airplane cockpit for training of pilots, air traffic control simulator (i.e. a control tower) for training of air traffic controller ATC, airport ground station simulator for the preparation of member of ground support. In our case we used two airplane cockpits, one ATC simulator and one airport ground station simulator. The core of all simulators for training of military personnel in aviation was Lockheed Martin's Prepar3D simulation software. It is necessary to emphasize one essential fact, simulators are based on commonly commercially available software and hardware. The workplace is compatible with Microsoft Flight Simulator X. The workplaces consist of two basic elements: the visualization system and the virtual console. Visualization systems are based on commercially available monitors of computers. Virtual consoles contain elements (rudder pedals, centre stick, etc.) to represent the cores of workplaces of individual members of air force. HW interface is built on a modular system of IO Cards Simulation System. IO Cards Simulation System is linked via the Flight Simulator Universal Inter-Process Communication to the Microsoft Flight Simulator X software. The VR Group Ltd. (Prague, Czech Republic) is the manufacturer of system of simulators. All simulators are located in separate rooms. Communication between simulators is ensured through an intranet. The simulators allow us to store the following data: latitude, longitude, heading, altitude, pitch, bank, airspeed, flaps position, vertical speed, etc.

The data from simulators for training and system for monitoring physiological data were synchronized by the trainer's command i.e. physical activity recorded by both group of systems. Systems collected data at a sampling rate of 1 Hz.

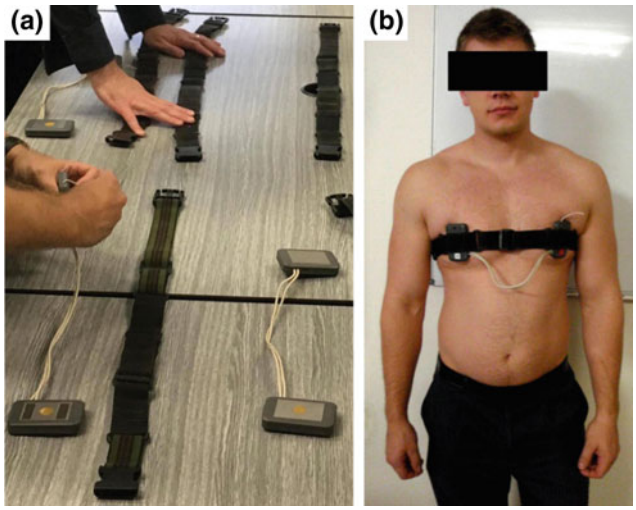

Fig. 1 Preparation (**a**) and application (**b**) of modular sensing units

2.3 Test Procedure

The proposed systems are used for simultaneous measurement of the working performance and physiological data of members of the four-member team (two pilots, one ATC staff and one ground staff member) during their training. Twenty-eight subjects were divided into seven groups of four members. Thus, four subjects were measured at the same time. Before each measurement, four portable systems for the monitoring physiological data were placed on the trunk of each soldier in accordance with [6, 7], see Fig. 1.

Then, two airplane cockpit simulators, one air traffic control simulator and one airport ground station simulator were used for training of military mission. The instructor proposed a list of tasks that all team members had to perform. It was all about ten types of different tasks. The commander-instructor monitored the performance of tasks by individual members and their physiological data, see Fig. 2. All data was stored for the following evaluation.

2.4 Method of Data Processing

The recordings of the data obtained during performing the tasks of each group on simulators are approximately a half of an hour long to 45 min. The records of physiological data and data from simulators can be processed to study the health conditions of staff members. This process was done using a custom-designed MatLab program based on the functions of the MatLab software.

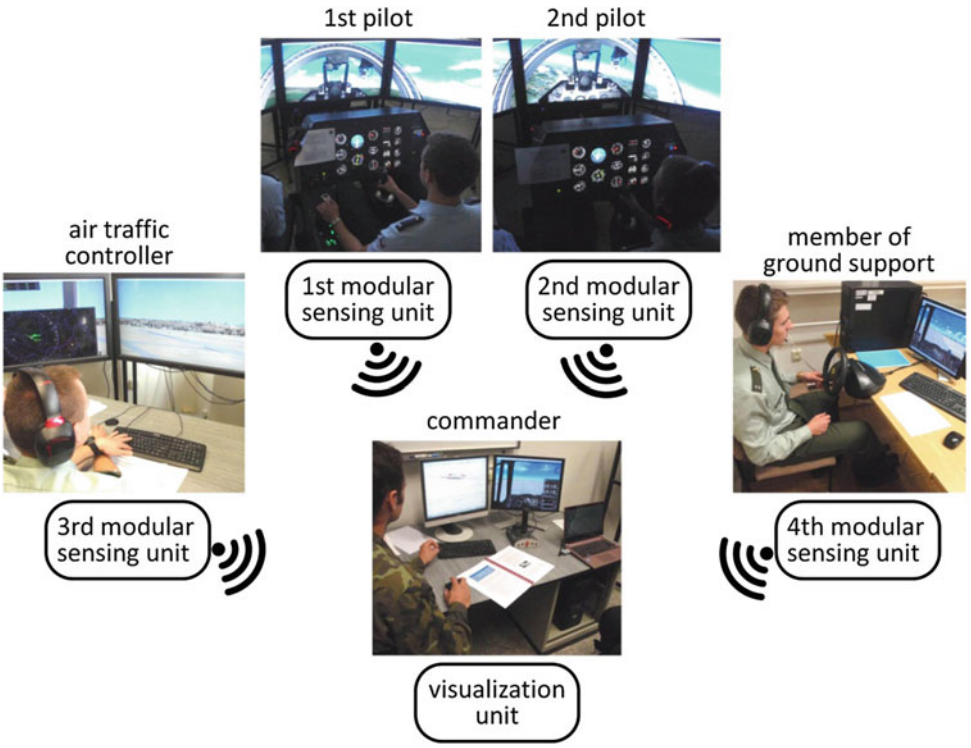

Fig. 2 Concept of the designed physiological data monitoring of members of air forces during training on simulators

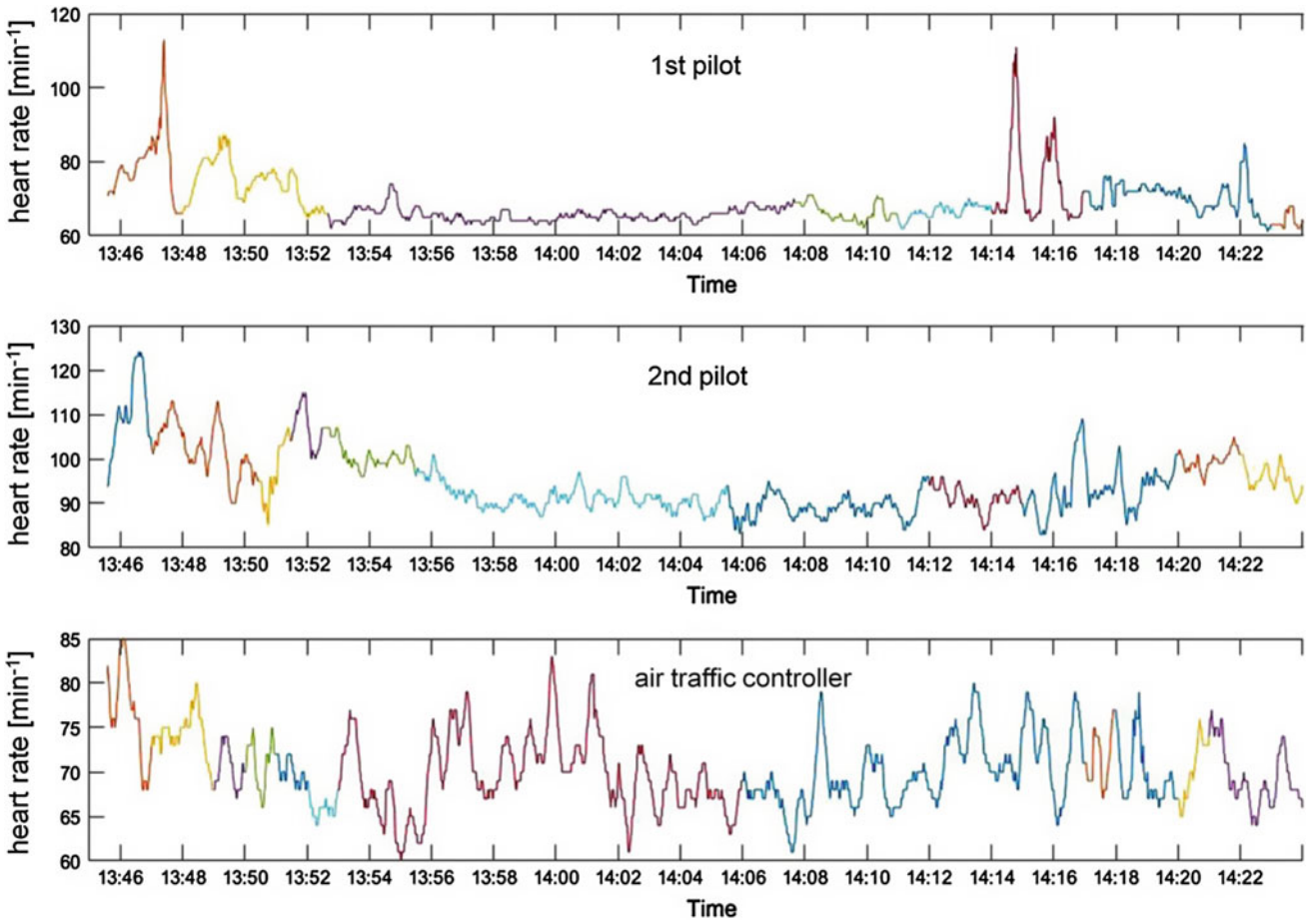

Fig. 3 Example of the output from user sw: real-time heart rate graphs of selected team members during training with color differentiation of performed individual tasks required by instructor (Color figure online)

3 Results

Preliminary results showed that there are dependencies in the development of physiological parameters of individual subjects in the team, although the correlation does not show causality. These dependencies are strong among pilots and controlling traffic controller, see Figs. 3 and 4, with less dependency identified in member of grout support. This is especially noticeable at the beginning of the start measurement, where the highest heart rate value is identified for all three members. Heart rate values are slowly decreasing after the start of aircrafts. Values of heart rate are gradually rising again when landing. The reason for this is that the start and landing of the most challenging phases of the flight for cadets-pilots, and the finding is that air traffic controllers are also responding to this, though not so much. Similar outputs are found for all measured teams. Preliminary results also show an increasing temperature of the body surface of all three members of team during the task on the simulator. Thus, the preliminary results showed higher correlations among the subjects above mentioned.

4 Discussion

Authors present how the modules of monitoring system were designed, training simulators adapted, and measurement and tests were performed. Testing of the functionality of the methodology took place on the training means of the army of the Czech Republic. In the case of carrying out the measurements on seven groups (i.e. 28 soldiers) of members of air forces during training on simulators, the sensor and simulator networks worked without any bigger problems. Preliminary results show higher correlations in biomedical data among the team members. From the results, we can assume that the monitoring system and training simulators allow us to study physical and psychological state and eventually identification of dangerous situations in the staffing of the military mission. However, this needs to be

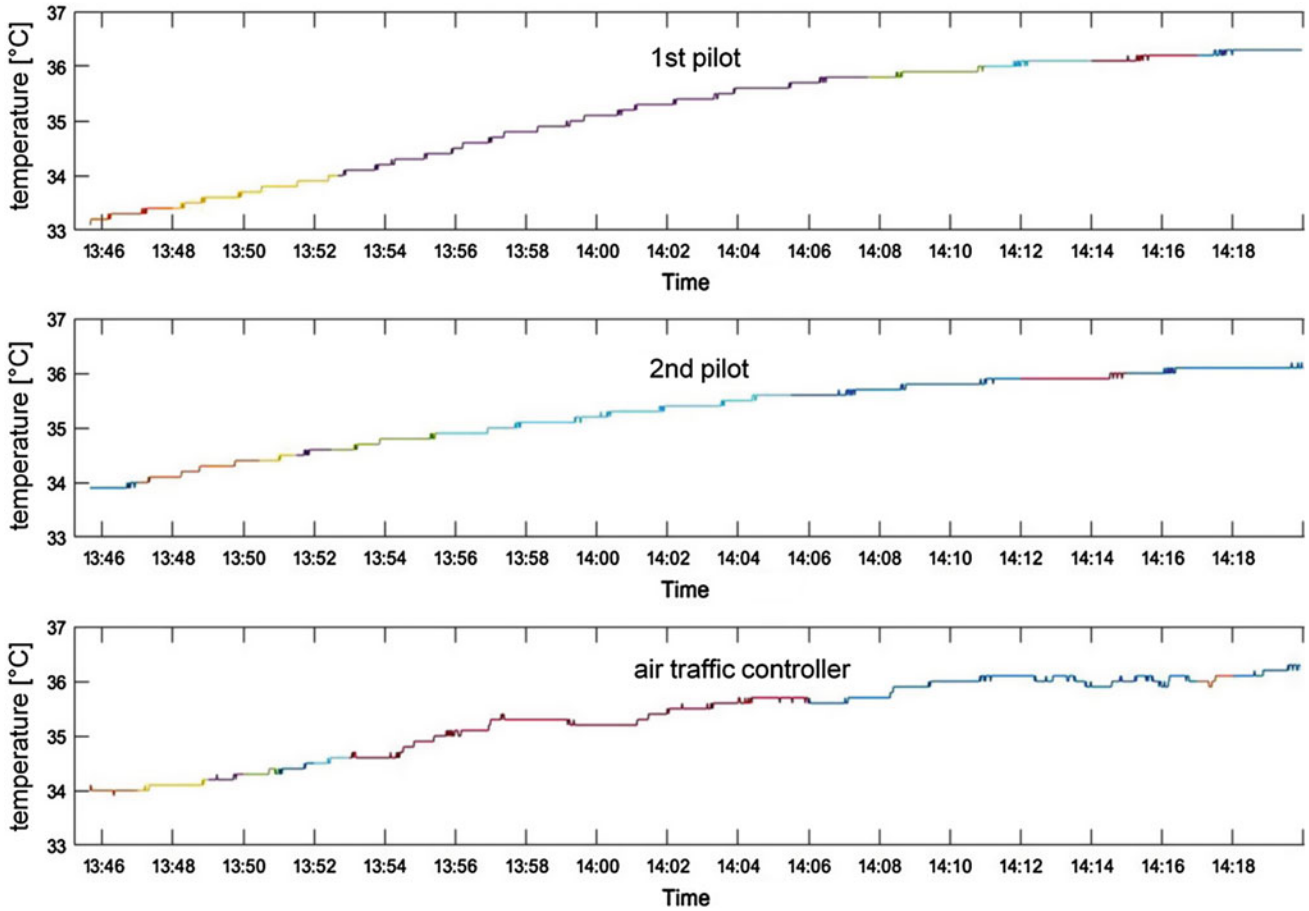

Fig. 4 Example of the output from user sw: real-time temperature graphs of selected team members during training with color differentiation of individual tasks (Color figure online)

further explored in future studies. We can say that low body temperature and heart rate could refer to better physical and psychological state and vice versa [7]. Thus, the systems and technique can offer information which may help to monitor the stress load level and operational preparedness of members of air forces. The assumption of research is future use of the technique in practice.

5 Conclusion

The proposed methodology and measurements were tested on 28 members of Air Force of the Czech Republic. Described preliminary findings demonstrate the ability of the proposed systems and measurement techniques to identify differences in the health state of team members of Air Force during training. The method can be used for quantifying in mental and physical state of the team members. Next goal is to verify the method on more subjects measured over more complex training missions, and integrate the system into practice.

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Conflict of Interest The authors declare that they have no conflict of interest.

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