INNOVATIVE BIOMONITORING SYSTEMS IN THE AEROSPACE INDUSTRY

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Abstract

The article presents the development of space telemedicine. The main biomedical parameters of astronauts from the International Space Station (ISS) are presented. The results of a project for a space medical center at a space airport of students from Nikola Vaptsarov Naval Academy - Varna and Medical University - Varna were discussed. The project was presented at the international competition Student aerospace challenge, the European Space Agency (ESA). Particular attention is paid to the innovative Astroskin Bio-Monitor system. The report proposes the creation of: a medical satellite system, Medical Data, Artificial Intelligence (AI) software, and surgical robots to permanently monitor, diagnose, and make decisions on astronaut health. A block diagram of the interaction between the "healing system (artificial intelligence + physician) and the astronaut patient" is presented.

1. INTRODUCTION

The up-to-date problem of the application of innovative biomonitoring systems in the aerospace industry stems from:

- The large number of ISS-related projects requiring astronauts to stay in space for a longer period of time;
- Space programs are being developed to: create moon bases; to launch and develop space tourism.

This requires a very rapid development of the methods and means of space telemedicine.

2. SPACE TELEMEDICINE

Telemedicine has been and will be vital to space travel, as astronauts must have access to treatment by a doctor even though they are thousands of kilometers away from the Earth.

NASA's first space-based telemedicine connection was created as part of Spacelab's ten-day mission in the 1990s. Then, for the first time, doctors from the Mission Control Center could explore images of the astronaut's heart. Today, thanks to improvements [6] in satellite communications, space agencies have expanded the applications of space telemedicine. In our time, astronaut medical services combine preventive, therapeutic and diagnostic assistance.

Innovation in space medicine is growing thanks to the commercialization of new space companies such as Richard Branson's Virgin Galactic. In August 2017, SpaceX transported the TechShot processor for advanced spacecraft experiments for regenerative medicine at the International Space Station (ISS).

2.1. Medical problems solved by the methods of space telemedicine

Radiation and microgravity affect the physical and psychological state of astronauts. This requires continuous medical control of their health and employability. Telemedicine is an important component in the medical service of astronauts at the ISS. Space Telemedicine enables preventive, diagnostic and therapeutic care for many months in space and ideally allows permanent care for the crew before and after space missions [2, 4].

Telemedicine combines medical equipment with a well-planned and tested communication system that enables the safe transfer of medical data, other information and expertise from the ISS to the Earth and vice versa, if necessary.

When a crew member has a medical problem, the first action is a video link to a surgeon.

A case is known [1] in which a member of the ISS crew with a history of knee trauma (no pre-mission symptoms) received severe knee pain while training with a nursing device. In an organized private medical conference, the physician from the Earth asks for an ultrasound of the affected joint. After reviewing the full set of images (downloaded from the ISU within an hour), the radiologist has confirmed the problem and prescribed treatment. The astronaut has seamlessly accomplished the mission.

Astronauts are now undergoing longer missions onboard the space station, which provide important data on long-term physiological effects in microgravity. Other challenges for the crew in space are: physiological adaptations to microgravity, radiation exposure, extreme temperatures and vacuum, and psychosocial reactions to the space flight. Ten dozen years ago, doctors noticed that crew members returned with marked structural changes in their eyes. The condition is called Space flight-associated neuro-ocular syndrome (SANS) [3].

2.2. Innovative astronaut condition monitoring systems

Some of the astronauts' health problems are solved by ultrasound review. Ultrasound is mounted to be able to send data efficiently by means of a limited and stable planned connection to ground control and using water instead of ultrasonic gel, which would be one more thing to be delivered to the station regularly. But it has also been changed to be as user-friendly as possible by non-medical professionals who have gone through the process from a remote targeting team.

A portable vital signs monitor Tempus Pro has been developed [11]. He conducted telemedicine via satellite, helping the medics to study the state of ESA astronauts on landing.

For exploration of the Space flight-associated neuro-ocular syndrome, NASA delivers a special scanner, an optical device for coherent tomography to the ISS station.

The intelligent clothing Astroskin [9, 10] is at trial. It brings together data from Earth and Space health studies. Astroskin includes the most modern monitoring of blood pressure, pulse oximetry, 3-channel ECG, breathing, skin temperature and activity sensors for 48 hours continuous real-time monitoring. The system includes iOS for iPhone and iPad, data synchronization software, and web dashboard. It is already in use at ISS (2018).

Figure 1. ASTROSKIN [10]

Robots are helping the astronauts. After NASA's Robonaut, Interactive Robot CIMON (Crew Interactive MObile CompanioN) [8] first appeared on the ISS in 2018 and has artificial intelligence.

Figure 2. CIMON (Crew Interactive MObile CompanioN) [8]

„Flying Brain", as Simon is called by his creators, has established visual contact with an astronaut, shot it and recorded a video. But it is not used to establish medical indices.

On June 13, 2019, NASA and ESA astronauts completed the final stage of the Airway Monitoring experiment [9]. The purpose of this experiment is to investigate the influence of circulating dust in space on astronaut's lung health.

3. PROPOSALS TO EXPAND THE CAPABILITIES OF SPACE TELEMEDICINE

Teachers and students from the Naval Academy "N. Vaptsarov" – Varna have been working on various space issues for several years in NASA [5] and ESA projects. Students from the Naval Academy have traditionally participated in the international competition of the European Space Agency Student aerospace challenge [7]. For the first time this year a team of students from our Academy and the Medical University – Varna participated in this competition. They have prepared a space medical space project for a space airport that will provide medical assistance to future space travelers. The project was honored by over a hundred proposals and attracted great interest in the final conference of the competition in June 2019 at the ESA Aerospace Center in France. One of the problems that the team has developed has been related to the possibilities of space telemedicine and the expansion of its capabilities.

Figure 3. Telemedicine for space travellers [7]

Particular attention is paid to the device astroskin. Astroskin could be upgraded and developed from the existing type of "jingle" to the options: "t-shirt – shorts" and/or "long pants – sweater without hood". For additional diagnosis, "we suggest adding a forehead or an astroshade strip consisting of metallic threads with special sensors and brain condition monitoring transmitters. It is of utmost importance for each space agency to use the medical data on the Earth in a computer before flight (pre-flight comparison data), astroskin for continuous observation, ultrasound for medical critical situation and and Tempus Pro on landing. The data are collected in the Medical Database. Artificial Intelligence in the ISS makes an analysis if there is a difference in the indicators in the Medical Data Base, decides to consult with a doctor on duty and co-ordinates with it a decision for possible treatment; provides medical information and recommendations to an on-board robot-surgeon.

We also offer a system of LEO medical satellites at a height of 100 to 500 km to collect and store ISS data as well as to make contact with Earth doctors in a more sophisticated medical case.

Another proposal is to extend the Robonaut robot functions. Surgical functions are added (Figure 4). We suggest that the robot walk around a rail around the astronaut's bed and perform an operation (if necessary).

We plan to develop "smart glasses" to prevent the impact of cosmic rays on astronaut's eyes. In addition, in their design, we propose to incorporate sensors to monitor the state of the internal organs like iris diagnostics. In this way, initial eye changes could be diagnosed as a result of the lack of gravity

Figure 4. Robonaut – with advanced medical manipulation capabilities [12]

We propose a block diagram of the interaction between the "healing system (artificial intelligence + physician) and the astronaut patient" – Figure 5.

The robot with an artificial intelligence must have self-learning features by receiving information from the Internet. AI can view and analyze video footage by self-learning and creating instruction for preparation, the materials needed to do so, and whether it is possible for himself / herself to perform the steps he / she has analyzed and recorded. The robot can analyze the success rate of human-made operations and assess the possible success rate of a possible operation.

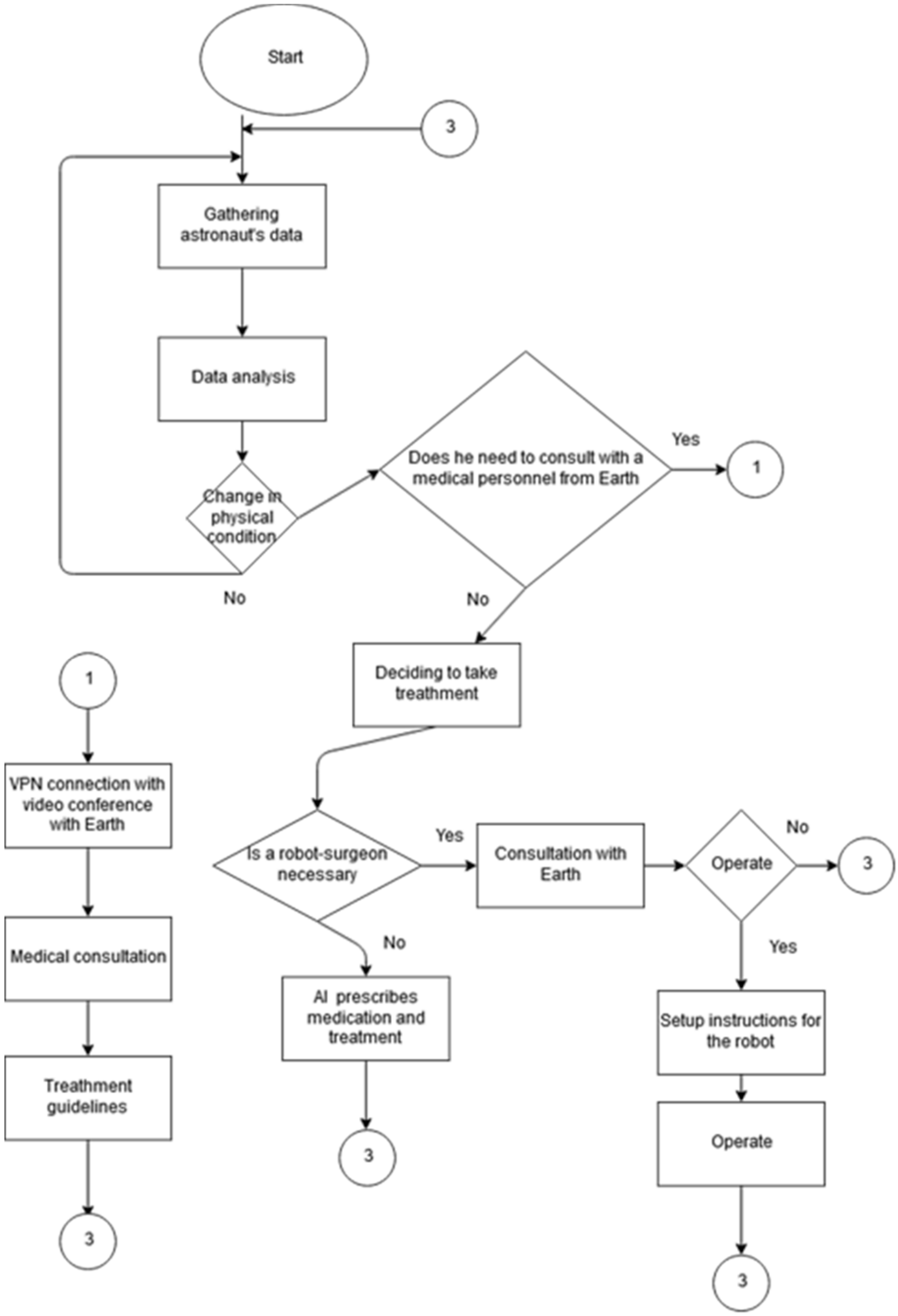

Figure 5. Block diagram of the interaction between the "healing system (artificial intelligence + physician) and the astronaut patient"

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4. CONCLUSION

The role of space telemedicine is growing with the rapid development of space flight technology for people. The suggestions made by the authors are applicable to existing and future space centers.

Innovations such as artificial intelligence robot-surgeons will greatly enhance the quality of life and work of astronauts. They are the basis of the future cosmic telemedicine, which will be the key to the success of the acquisition of the near and far space.

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