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COSMO-AI: An AI-Based Health Monitoring and Wellness Assistant for Astronauts in Space

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Abstract:

During long space missions, astronauts face numerous challenges including physiological stresses and extreme mental pressure, as well as the lack of health care assistance. With a delay of up to 24 minutes for each signal between Earth and Mars, physicians on Earth are unable to provide immediate assistance during an emergency. This paper introduces the COSMO-AI concept, an AI health assistant and monitoring system that can provide wellness support and address health concerns. The proposed architecture is built around lightweight wearable sensors that allow continuous tracking of vital signs and other key physiological metrics such as blood oxygen levels, heart rate, body temperature, and sleep quality. In addition, the system provides an in-cabin-offline AI assistant to assist astronauts with relaxation and mental wellness by engaging in natural language conversations and analyzing mood and behavior. COSMO-AI can maintain encrypted electronic health records and autonomously issue emergency alerts when necessary. The proposed architecture is realistic and deployable within the current spacecraft and space station designs. Index Terms - Astronaut Health, AI Health Assistant, Wearable Sensors, Space Medicine, Mental Health, Offline AI, Emergency Alerts, Deep Space Missions

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I. INTRODUCTION

One of humanity's greatest scientific achievements, space exploration, is full of danger for those who leave the planet's protective cloak. Travel to the Moon, Mars, and beyond presents astronauts with challenges that basic clinical preparation does not cover. It includes extended periods of isolation with microgravity and elevated radiation exposure as well as disrupted circadian synchronization and psychosocial strain from extended travel so far from home.

A significant obstacle for deep space travel is the lack of availabilities for medical support. For signals going to and returning from Mars, there will be a downtime of 4 to 24 minutes; consequently, the crew will have to make a decision about the medical emergency using their best judgment and what's available onboard. Presently, astronauts aboard the International Space Station (ISS) have the advantage of frequent and prearranged exams. Exercise programs, and near-instantaneous communication with flight surgeons.

Mars-bound crews will not have that luxury [3].Artificial intelligence and wearable sensor technology together offer a compelling path forward. An AI health system can track physiological data around the clock, recognize the early signatures of health deterioration, offer evidence- based medical guidance, and provide meaningful psychological support — all without any link to Earth [4]. The question is no longer whether such a system is feasible; the question is how to build one that is reliable, integrated, and truly comprehensive. This paper presents COSMO-

AI a practical, self-contained AI health assistant designed for astronauts on long-duration missions. The system is built to:

• Monitor physical health continuously using multi-parameter wearable sensors;

• Detect early signs of stress, fatigue, and emotional distress;

• Provide an offline AI companion for mental and emotional support;

• Generate autonomous emergency health alerts with first-aid guidance;

• Maintain secure, longitudinal health records for mission physicians and space medicine researchers.

The goal of COSMO-AI is straightforward: ensure that astronauts remain physically healthy, psychologically resilient, and well-supported throughout every phase of their mission even when they are millions of miles from the nearest doctor.

II.RELATED WORK

Xygkou-Tsiamoulou et al. [1] proposed COSMIC, an emotionally intelligent AI agent designed to support the mental and emotional well-being of astronauts during long duration space missions. The system utilizes conversational AI and emotion recognition techniques to assess astronauts' psychological state and provide personalized emotional support.

Kumar et al. [2] introduced MAIDS (Medical AI Doctor in Space), an AI-based virtual medical assistant developed to provide autonomous healthcare support during space missions. The system is capable of analyzing symptoms, offering preliminary diagnoses, recommending treatments, and assisting astronauts when communication delays make immediate consultation with Earth based medical experts impossible.

Patil et al. [3]npresented an AI-enabled space crew health monitoring system that combines wearable sensors with machine learning techniques to continuously monitor astronauts' physiological parameters. The proposed system collects real-time health data, identifies abnormal conditions at an early stage, and supports timely medical intervention.

Wang et al. [4] reviewed the latest developments in flexible wearable devices for astronaut health monitoring. Their study discusses wearable technologies capable of tracking vital signs such as heart rate, body temperature, respiration, and movement while ensuring comfort during prolonged missions. The authors also address challenges related to sensor accuracy, durability, power management, and reliable performance under space conditions.

Smith [5] investigated the application of automated psychotherapy in spaceflight environments. The study evaluates how AI-driven psychological support systems can provide counseling and emotional assistance to astronauts during extended missions. It also discusses the potential advantages, ethical considerations, and limitations of replacing or supplementing human therapists with intelligent virtual systems.

Osman [6] proposed an AI-based healthcare monitoring system that performs continuous health assessment using artificial intelligence techniques. The system analyzes physiological data, detects abnormalities at an early stage, and supports medical decision-making. The research demonstrates how AI can improve healthcare efficiency through real-time monitoring and predictive analysis.

Greatbatch [7] reviewed the expanding role of artificial intelligence in space medicine. The paper discusses various AI applications, including disease diagnosis, clinical decision support, predictive healthcare, and mission planning. It emphasizes that AI technologies can significantly improve medical autonomy and healthcare quality during long-duration space missions.

Khan et al. [8] explored the physiological effects of spaceflight on the musculoskeletal system and discussed the role of wearable technologies in monitoring astronaut health. The study highlights how wearable sensors can continuously assess muscle activity, movement, and physical performance, enabling effective countermeasures against muscle loss and bone density reduction in

microgravity.

Scott et al. [9] proposed a precision health framework that integrates biomonitoring, wearable sensors, and artificial intelligence to support astronaut healthcare during deep-space missions. The framework utilizes machine learning algorithms to predict health risks, personalize medical care, and enable early intervention, thereby improving mission safety and crew well being.

Scott and Sanders [10] discussed the application of machine learning in biological research and astronaut healthcare. Their work explains how AI can process complex biomedical datasets, support scientific discoveries, and enable autonomous healthcare systems for future lunar and Mars missions.

III. PROPOSED SYSTEM

A. System Overview

COSMO-AI is a wearable AI health assistant that functions without an internet connection and provides assistance with both psychological and physiological health to astronauts. The system consists of three closely connected sections:

1) Health Monitor - a small device that is used to measure vital signs through the mission.

2) Onboard Artificial Intelligence Engine - handles the incoming data stream, conducts the health analysis, generates notifications, and makes recommendations.

3) AI companion - an offline talking machine that provides emotional support, mental engagement, and motivation.

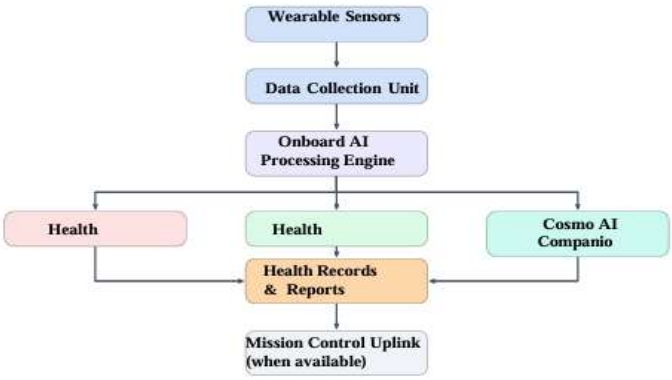

Fig.3.1 Architecture of COSMO-AI system displaying data transfer from wearable devices and AI engine to health alerts, Cosmo companion, health records, and Mission Control

IV.METHODOLOGY

A. Gathering Data from Wearable Sensors

To monitor their physical conditions in space, a small, portable health monitoring equipment is placed on each astronaut to continuously gather multi-parameter vital sign information. In Table I, the health parameters, monitored and recorded by the various sensors of the wearable equipment, have been summarized. The entire process of monitoring is presented in Fig.2.The raw information collected from all the sensors is sampled every few seconds and conveyed wirelessly to the onboard Artificial Intelligence computers.

TABLE I SENSORS INTEGRATED IN THE COSMO-AI WEARABLE DEVICE

Sensor	Indicator	Medical Description
Heart beat Sensor	Number of beats in a minute	Health of heart and stress
SpO_2 Sensor	Oxygen in blood (%)	State of breathing
Temperature sensor	Temperature of body (°C)	Fever, disease, tiredness
Accelerometer	Moving and steps taken	Level of activity and stage of sleep

The AI has access to collected information and uses it to assess the astronaut's medical measurements with reference to the specific baseline that has been defined during the training prior to the flight [3]. Whenever a obtained reading strays from the defined accepted range, the system starts the processes that are described below automatically.

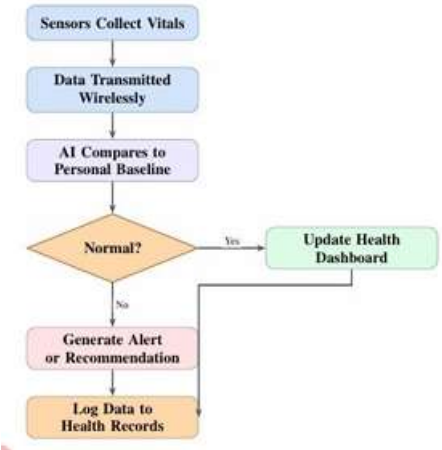

Fig.4.1. The procedure of wearable health monitoring. The sensor data is collected and sent to the AI engine, where it's compared against each astronaut's personal baseline.

B. Analysis in AI Medicine

AI provides six functions in analysis in real-time:

• the analysis of vital sign data (e.g., low blood oxygen level, rapid heart rate, fever);

• analysis of heart rate variability and skin conductance;

• the assessment of sleep;

• the measurement of fatigue;

• the calculation of Daily Health Score from 0 to 100;

• the optimization of thresholds.

In its essence, analytical core technology merges uncomplicated, clear-cut rules with basic pattern detection techniques. For instance: should an astronaut's heart rate be above 100 bpm for more than 5 minutes, or if he is below 90% in blood oxygen saturation levels, an emergency medical alert is put into action immediately. These thresholds are constantly adjusted to fit each crew member's unique profile, preventing a great number of false alarms and important occurrences being overlooked.

C. Emergency Response

When AI determines that a serious health event has occurred, COSMO-AI takes instant action using a four-phase process : the astronaut affected is presented with simultaneous audio/visual alerts; the rest of the crew is informed; step-by-step first-aid instructions are provided on the nearest onboard display; and a report containing details of the health event is prepared for sending to Mission Control at

first opportunity.

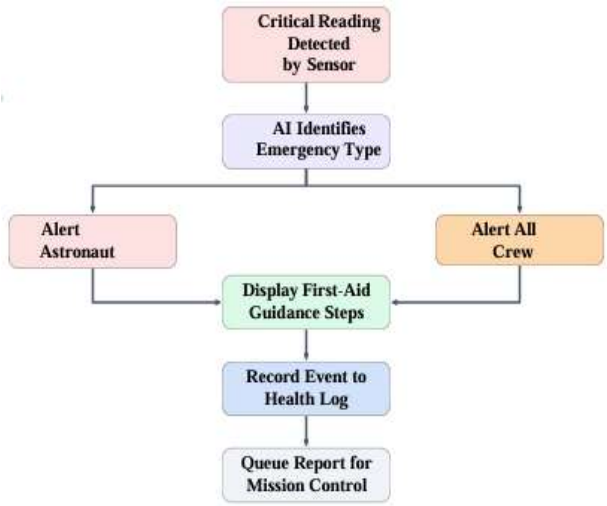

Fig.4.2. Emergency response process. When a critical reading is detected, COSMO-AI alerts the astronaut and crew simultaneously, provides first-aid guidance, and queues a medical report for Mission Control.

D. Society's Unique Features

Another important component of society is its unique companion system. Space voyages are heavily isolating experiences and managing psychological wellness is as important as managing physical wellness. In this regard, Society can provide the following:

• Ability to engage in a natural dialogue, thus alleviating feelings of loneliness;

• Tips on how to manage stress and perform different relaxation exercises;

• Support with meditation and other relaxation practices with the help of sounds of nature;

• Regular motivational messages which are adapted to the person's emotional conditions as per the situation.

E. Storage and Reporting of Health Data

All types of information obtained by COSMO-AI are kept in encrypted onboard storage. The information includes records of vital signs collected over time, detailed logs of sleep quality, as well as long-term records of stress and mood and summaries of exercise compliance. Data are provided with timestamps and can be used for comparing the data from pre-mission, in-mission and post-mission stages of the research.

V. SYSTEM FEATURES

In table II, the features of COSMO-AI have been listed in terms of their functionality.

Category	Features
Physical Health	Heart rate monitoring, SpO_2 tracking, body temperature surveillance, sleep staging, fatigue detection, hydration reminders, exercise guidance, medication reminders, daily health score, emergency alerts
Mental Health	Offline AI companion, NLP-based stress detection, mood journal, breathing exercises, meditation guidance, ambient nature sounds, motivational messages, loneliness support, mental wellness tracking
Data & Reports	Health history archive, pre-/post-mission comparison, trend analysis, mission health summaries, Mission Control data uplink
Smart Features	Personalized daily routine planning, circadian rhythm regulation, adaptive health reminders, AI-generated exercise plans, emergency SOS

A. Daily Health Score

Every morning, COSMO-AI compiles four sets of data into a Daily Health Score for every crew member: the quality of sleep from the previous night, the day's morning vital signs, accumulated stress indicators, and the physical activity for the previous day [5]. The score will be displayed on the astronaut's wristwatch as well as on the main cabin screen. A score of above 80 points indicates that the health condition is good. The scores that fall between 60 and 80 points raise moderate concerns and result in advice to be issued. The scores below 60 points, on the other hand, trigger health intervention actions.

B. Support for Circadian Rhythm

The lack of day-night light cycle in space stations is a well-known reason for sleep problems and stress in astronauts. COSMO-AI tackles this issue through the correct management of light in the cabin. To help maintain alertness and decrease melatonin levels, the cabin is filled with bright blue light during the day; at night, soft and warm lighting is used, allowing for natural sleep. The system also sends personalized reminders each crew member receives at a specific time based on their unique sleep and wake schedule

C. Operation Without Online Performance

From sensors acquisition to AI processing, from the Cosmo tool to logging health data, and sending emergency alerts, everything is fulfilled offline on the spacecraft's computer system. Moreover, there is no need to connect to the Internet in the process. The mentioned approach is obligatory for deep-space missions as they entail communication delays up to 48 minutes while reaching Mars.

VI. EXPECTED RESULTS AND OUTCOMES

COSMO-AI is now at the stage of conceptual design and prototype specification. The results presented in this section are based on the rationale behind the design of the system and the findings of the existing literature reviewed in Section II.

A. Past Physical Health Detection

The capacity of wearables for continuous monitoring is inherently superior to periodic manual checks in order to detect early stages of health deterioration [6]. COSMO-AI aims to detect abnormal vital sign trends in near real time, reduce the incidence of undetected health decline and improve adherence to exercise and medication schedules through its smart reminder system [3].

B. Better Mental Health

The Cosmo companion is supposed to make people feel less lonely and stressed out over periods of time. Studies have shown that when people are isolated, talking to others and getting help for health issues really makes a big difference. It helps people perform better feel more stable and cope with problems over time. The Cosmo companion also lets astronauts write down their feelings and check in every day which gives them a way to deal with their emotions.

C. Faster Help In Emergency Situations

Now if an astronaut has a medical emergency they have to figure out how bad it is and then wait a few minutes to get help from Earth. The Cosmo companion changes this. It can detect problems automatically show what to do away and tell the rest of the crew at the same time. This makes a difference, in how fast and well people respond to emergencies. The Cosmo companion really improves how people react in emergency situations.

D. Longitudinal Health Research Data

The comprehensive health records collected across multiple crew members and missions will constitute a scientifically valuable longitudinal dataset for space medicine research. This data will help scientists build far richer models of

how extended spaceflight affects human physiology and psychology overtime [7].

TABLE III
EXPECTED OUTCOMES OF THE COSMO-AI SYSTEM

Area	Expected Outcome
Health Monitoring	Continuous, real-time, early-stage detection
Emergency Response	Faster, automated, step-by-step first-aid
Mental Health	Reduced stress, less isolation, better mood
Sleep Quality	Improved sleep via circadian rhythm regulation
Data Collection	Complete longitudinal records for research
Offline Operation	Full system functionality without Earth contact

VII. FUTURE SCOPE

COSMO-AI is a platform that has been developed with the goal of expanding as technology in space and artificial intelligence develops. In the future, developments may allow better healthcare for astronauts and safe missions and enable the intuitive decision-making ability during long-term missions in space.

1) Crew Health Coordination:

The company in question has the ability to track and assess all team members' health on a simultaneous basis. It is possible to detect patterns like stress, fatigue and decreased efficiency, thus enabling commanders to make optimal decisions about dividing loads, establishing schedules and ensuring crew safety.

2) Medical System Robotic Integration:

COSMO-AI can work with medical robotic systems installed on board the spacecraft to perform such tasks like wound treatment, medication preparation and distribution, health control, and other emergency tasks. This application will allow to enhance the efficiency of medical response and minimize astronauts' workload.

3) Nutrition Using Artificial Intelligence:

The system manages the nutrition of astronauts and calculates their energy consumption, thus allowing personalized recipes to be created so the astronauts can remain healthy and productive for a long period of time.

1) Voice-Controlled Mechanism:

COSMO-AI can also be enhanced with the voice-based mechanism that allows communicating with the system via voice commands. This unique approach will allow the astronauts to complete experiments, fix issues, and perform other important tasks without the need to use their hands.

4) Digital Twin:

COSMO-AI can create a digital twin of every astronaut based on the medical and physiological information accumulated during the mission. The digital twin is the way to assess possible health risks and suggest simple preventive measures.

VIII. CONCLUSION

In this paper, we have introduced COSMO-AI, an all encompassing AI concept that has been designed for long-lasting journeys in space. The presented concept consists of numerous multi-parameter devices, which allow us to permanently monitor physiological state of an astronaut and an onboard intelligence component responsible for making instant diagnosis and autonomous medical decision making and support. Another component operates offline, providing psychological support. The main advantage of COSMO-AI is the integration of all sections of this system. While most of previous developments deal with particular elements of the system such as diagnostics or monitoring, COSMO-AI brings everything under one component that is working effectively.

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