AstroVitals AI: Intelligent Monitoring for Astronaut Health in Space

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Track Chosen: Conceptual Design Track

Course: ITAI 2372

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1. Project Proposal

Title: AstroVitals AI — Real-Time Health Monitoring for Astronauts

Objective:

Develop a conceptual AI solution designed to monitor astronauts' health during space missions in real-time. The system will predict and alert for potential health risks, enhance decision-making support, and provide insights for remote medical teams.

Background & Motivation:

Long-duration missions (ISS, lunar bases, Mars) expose astronauts to health risks including radiation, cardiovascular changes, and psychological stress. Traditional monitoring is passive and depends on post-incident intervention. AI offers an opportunity for early detection and continuous prediction, increasing astronaut safety.

Significance to NASA Missions:

- Enhances autonomy during long-duration, deep-space missions.

- Reduces reliance on Earth-based medical intervention.
- Prevents mission disruption through predictive alerts.

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2. Solution Design

System Overview:

AstroVitals AI is a multi-layer system combining biomedical sensors, edge AI processing, and a deep learning model trained on Earth-based astronaut analog data.

Key Components:

- **Input Data:** ECG, EEG, blood pressure, heart rate, O2 levels, stress indicators (galvanic skin response), and facial emotion recognition via embedded cameras.
- **Edge AI Module:** Processes sensor data in real-time using compact neural networks on edge devices.
- **Central Model:** A hybrid system using:
  - **LSTM networks** for temporal pattern recognition (e.g., arrhythmia prediction)

    - **Anomaly detection models** for rare medical events
    - **Computer vision models** for facial stress detection
- **Dashboard Interface:** Sends alerts and summaries to the crew and mission control

Data Flow Diagram:

(Sensor Inputs) → [Edge Processing] → [AI Health Engine] → [Alerts + Visual Reports]

Anticipated Use Cases:

- Early prediction of cardiac irregularities
- Stress level analysis during high workload periods
- Oxygen desaturation detection in EVA

Deployment Architecture (Conceptual):

- Raspberry Pi/NVIDIA Jetson for edge AI compute
- Secure local database synced with Earth-based system (when bandwidth allows)

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3. Testing Plan

Simulation-Based Validation:

- Use Earth-based analog environments (e.g., HI-SEAS, HERA, NEEMO) datasets for modeling and testing.
- Compare predictions against medical logs from analog astronauts
- Use stress and cardiovascular datasets from astronauts pre/post-mission for retrospective testing

Evaluation Metrics:

- Precision/Recall for anomaly detection
- Time-to-alert for emergent health issues
- False positive/negative rates

AI Model Verification:

- Test LSTM model using time-series datasets of vital signs

- Validate facial emotion detection using NASA's Emotion Face Dataset

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4. Resources & Future Work

Resources:

- PhysioNet (MIT Health Data Repository)
- NASA Life Sciences Data Archive
- PyTorch/TensorFlow for prototyping models
- GitHub repo for documentation

Future Directions:

- Integrate with digital twin technology for astronauts
- Expand to include dietary intake + mental health journaling
- Enable autonomous recommendations (e.g., rest, oxygen boost)

Ethical Considerations:

- Data privacy + informed consent for biometric analysis

- Avoid over-reliance on AI over human judgment