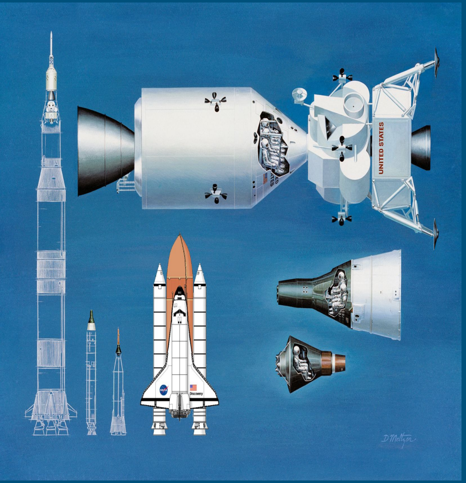
AI-Based Spacecraft Operations Assistant (AI-SOA)



ITAI 2372 Artificial Intel Applications

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Project Overview

- Space missions face challenges like real-time decision-making, resource management, and anomaly detection. These challenges are amplified when communication with Earth is delayed, requiring autonomous systems to ensure mission success.
- Solution Overview: AI-SOA is an AI-driven system that autonomously detects anomalies, optimizes resource usage, and makes real-time decisions to improve spacecraft operations and reduce reliance on Earth-based control.

Key Features of AI-SOA

- Anomaly Detection: Uses supervised learning to detect and flag irregularities in spacecraft telemetry data (e.g., unexpected temperature spikes, power failures).
- Resource Optimization: Implements reinforcement learning to optimize resource allocation (e.g., fuel, power) based on real-time mission needs and constraints.
- Decision Support: Rule-based system automates decisions during critical events (e.g., re-routing spacecraft, adjusting power to essential systems).

Testing Plan

- Test Scenarios: Simulating anomalies in telemetry data (e.g., sudden spike in temperature or power loss). Resource optimization under constrained conditions (e.g., limited fuel). Decision-making during critical events (e.g., sensor failure). Testing Metrics: Accuracy: Precision, recall for anomaly detection. Efficiency: Resource usage improvements. Response Time: Time taken for automated actions.

Evaluation Methods

- Metrics for Success: Confusion Matrix for anomaly detection performance. ROC-AUC Curve for evaluating classification performance. Energy savings metrics to measure efficiency in resource optimization. Tools: Simulated data sets, Python unittest framework, and evaluation metrics like precision, recall, and F1 score.

Expected Benefits

- **Autonomy:** Reduces reliance on Earth-based control, enabling quicker responses in deep space.
- **Efficiency:** Optimizes resource usage, ensuring spacecraft can operate within limited resources.
- **Safety:** Early detection of anomalies helps prevent catastrophic system failures, improving mission safety.

Future Possibilities

- Expansion to Other Missions: AI-SOA can be applied to other space missions, from lunar exploration to Mars rovers.
- Human Spaceflight: Integration with human spaceflight missions to support astronauts' decision-making in critical situations.
- Scalability: The AI-SOA framework can be adapted for larger fleets of spacecraft or larger missions with more complex data requirements.

Conclusion

- Summary:
  AI-SOA provides a crucial solution for autonomous spacecraft operations, with benefits in anomaly detection, resource optimization, and decision support.
- Final Thoughts:
  This AI system paves the way for more autonomous, efficient, and safe space missions, reducing human intervention and ensuring mission success in challenging environments.

References

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   A research article on applying AI for resource management in space missions.
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