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April 22, 2015

Pattern Recognition and Expert Systems for Microwave Wireless Power Transmission Failure Prevention

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Available at: https://works.bepress.com/jeremy_straub/283/
Introduction

Wireless power transfer (WPT) can be used to deliver space-generated power to ground stations through the use of microwave beams. WPT satellite power delivery systems have two major failure states: misdirecting a beam and failing to send power to a station. This project has implemented an expert system to perform pattern recognition in an effort to prevent failures by analyzing the system state and predicting potential failures before they happen in support of space-based testing [1] and deployment [2].

Tools Used

For the purposes of demonstrating the proof-of-concept system, it was decided at the onset of the project that C# and the .NET framework would be utilized for expert system implementation. This provided numerous benefits, such as facilitating rapid development and easy access to a robust SQL server implementation in which the project’s knowledge base was implemented. An actual deployment could utilize these or alternate technologies.

To implement the knowledge base, two tables were created within the database: one to store rules, and one to store facts. In expert systems (see e.g., [3]), rules are statements about how the world and / or system works. They are typically formulated as if-then statements. They are typically static, and thus don’t change due to perceptions. Facts represent the systems (potentially incorrect or biased) view of reality; they provide the data required to make use of the rules supplied.

Connected to the knowledge base is an inference engine, which searches for rules whose preconditions are satisfied by known facts. These rules are executed, potentially asserting new (or refuting existing) facts. The combination of the engine and fact network are used to determine when a failure in delivering power from the satellite to the ground-based rectenna may be imminent. It does this by using forward chaining to detect when the satellite or receiver may be in a pattern that leads to failure. It can also assist in diagnosing failures when they occur.

The information generated by the system can be used by onboard or ground station autonomous controller software or provided to a user to make needed corrections. A model of this implementation is shown in Figure 2.

Background

Space-based solar power was originally suggested in 1968 by Peter Glaser [4] as a method of collecting and delivering solar power to Earth. At that time, technology wasn’t advanced enough for implementation, so the idea was abandoned for a time. Then, in 1995, NASA decided to take a second look at the concept, as technology had advanced, and the idea seemed more feasible [5]. Again, the idea failed to gain traction as the costs and difficulties seemed to outweigh the potential benefits. More recently, advances are painting the technology in a different light [6], suggesting numerous possibilities for its use.

Forward Chaining

The forward chaining that is the primary technique used in our inference engine is based on the laws of Boolean logic. This is due to how well such a representation works with computers. An example of how forward chaining in space-based solar power might work follows. This is also visually depicted below in Figure 3:

- \( R \) := “synchronization beam received”
- \( P \) := “power received at ground station”
- \( L \) := “power collection is functioning”
- \( C \) := “power conversion is functioning”
- \( T \) := “transmission system is functioning”

The power of chaining comes from its inherent simplicity and ease of understanding (which is critical to allowing users to interact with a safety-critical system). While being conceptually simple, the logical statements that can be created through chaining make it able to represent numerous scenarios.

Conclusions and Future Work

Space-based wireless power collection and transfer was suggested by Isaac Asimov in his 1941 short science fiction story “Reason” [7] and today it is moving closer to becoming a reality. Moving forward, it is obviously important to be able to preemptively predict and prevent failures in these systems, as both misdirecting a beam and failing to supply power to a ground station that needs it could be catastrophic. Using expert systems and pattern recognition to detect such failures seems likely to be an effective approach to this. The work presented herein serves as a solid base to build upon in the future.

References

This poster is revised from [8].

References

1. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experimental Mis-


27. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.


34. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.

35. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.


40. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.


42. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.

43. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.

44. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.

45. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.


47. Berglund, C.; Straub, J. A Space-to-Space Microwave Wireless Power Transmission Experiment.

