Certification-Based Process Analysis

Technique analyzes a process and identifies potential areas of improvement.

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Space mission architects are often challenged with knowing which investment in technology infusion will have the highest return. Certification-based analysis (CBA) gives architects and technologists a means to communicate the risks and advantages of infusing technologies at various points in a process. Various alternatives can be compared, and requirements based on supporting streamlining or automation can be derived and levied on candidate technologies.

CBA is a technique for analyzing a process and identifying potential areas of improvement. The process and analysis products are used to communicate between technologists and architects. Process means any of the standard representations of a production flow; in this case, any individual steps leading to products, which feed into other steps, until the final product is produced at the end. This sort of process is common for space mission operations, where a set of goals is reduced eventually to a fully vetted command sequence to be sent to the spacecraft. Fully vetting a product is synonymous with certification. For some types of products, this is referred to as verification and validation, and for others it is referred to as checking. Fundamentally, certification is the step in the process where one insures that a product works as intended, and contains no flaws.

Candidate technologies are evaluated against a potential area of improvement using criteria such as risk, adaptation cost, adaptation time, reduction in cost, reduction in duration, reduction in risk, and maintainability. Where risk and maintainability are acceptable, and gains in either cost or duration outweigh adaptation costs, then the technology is deemed a suitable candidate. For many technologies, especially artificial intelligence technologies, certification of a technology implies the certification of the process (or process step) that the technology is used for, as compared to certifying the product (using a separate process, which, for space applications, is often manual). Certifying the process, and not the product, is the key tenet of CBA.

This work gives specific direction to architects on what operations can be allowed that are not usually allowed in modifying/designing architecture with respect to technology transfer. This work applies to any production process in general, but specifically it is being applied to spacecraft operations design, planning product production, and stowage product production.

This work was done by Russell L. Knight of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47692

Surface Navigation Using Optimized Waypoints and Particle Swarm Optimization

This technique could be used in search and rescue, tracking, military scouting, navigation, and as a field resource support tool.

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The design priority for manned space exploration missions is almost always placed on human safety. Proposed manned surface exploration tasks (lunar, asteroid sample returns, Mars) have the possibility of astronauts traveling several kilometers away from a home base. Deviations from pre-planned paths are expected while exploring. In a time-critical emergency situation, there is a need to develop an optimal home base return path. The return path may or may not be similar to the outbound path, and what defines optimal may change with, and even within, each mission.

A novel path planning algorithm and prototype program was developed using biologically inspired particle swarm optimization (PSO) that generates an optimal path of traversal while avoiding obstacles. Applications include emergency path planning on lunar, Martian, and/or asteroid surfaces, generating multiple scenarios for outbound missions, Earth-based search and rescue, as well as human manual traversal and/or path integration into robotic control systems. The strategy allows for a changing environment, and can be re-tasked at will and run in real-time situations.

Given a random extraterrestrial planetary or small body surface position, the goal was to find the fastest (or shortest) path to an arbitrary position such as a safe zone or geographic objective, subject to possibly varying constraints. The problem requires a workable solution 100% of the time, though it does not require the absolute theoretical optimum. Obstacles should be avoided, but if they cannot be, then the algorithm needs to be smart enough to recognize this and deal with it. With some modifications, it works with non-stationary error topologies as well.

A novel path planning algorithm has been developed, in coordination with PSO, that generates a piece-wise linear path from a set of optimal waypoints. The path is guaranteed to be continuous, though the problem space itself may be discontinuous. The path avoids obstacles while minimizing total path distance.