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Self-awareness for robust miner robot autonomy

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Robustness and resilience are crucial requirements for robots operating in unstructured and hazardous environments, such as the systems developed within the ROBOMINERS project. The miner robot shall handle, at least to some extent, the disturbances it may suffer; especially given the reduced possibility of human intervention in deep, small, and difficult-to-access deposits. In ROBOMINERS, we use self-awareness mechanisms to enhance robot miner autonomy. This capability enables the robot to be aware of the state of all its components (both hardware and software) and to what extent they are complying with their functions. Moreover, self-aware systems can reason about the run-time state and detect the causes of system failures. Depending on the specific characteristics of the affected robot, failure management mechanisms can be implemented at different levels. Robots can be designed to change their physical or software configuration, change the functions of some of their components, or adapt their behaviour to match mission needs. Our approach uses the knowledge of the systems engineer through machine-readable metamodels to provide the robot with information about the mission, the environment, and itself. These formal models allow the system to reason about its run-time situation. The ROBOMINERS resilience-augmenting solution is based on deep modeling of the functional architecture of the autonomous robot in combination with runtime reasoning. The reflective reasoning of the robot allows for both self-diagnosis and reconfiguration during mining operations. One of the main advantages of this knowledge-centric approach is the explicit definition, allocation, and linkage of system requirements, design decisions, system realization, and run-time information. This approach can transparently use robot structural and functional redundancy to ensure mission satisfaction, even in the presence of faults. Moreover, the use of several meta-models and ontologies allows the segmentation of information into different domains and levels of abstraction. These independent assets can then be re-targeted and adapted to a variety of systems, sub-systems, and contexts to improve asset reuse.