Safer Soccer
The Immune System of (Austrian)Kangaroos

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Austrian Kangaroos
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I. Motivation

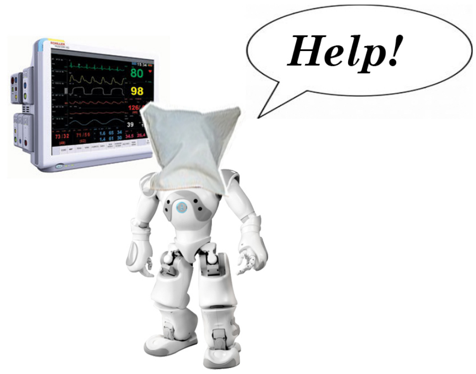
Like real life forms, robots suffer from various defects such as environmental but also self-induced malfunction. Nature has evolved the concept of immune systems to cope with unexpected and unpredictable malicious effects like illness or injury. Technical systems like robots typically rely on fault-detectors and error handlers that are based on a complete enumeration of possible errors and a classification of faults. Therefore, only faults foreseen at development time can be properly detected and even be recovered.

Robots operate within an inherent non-deterministic environment: the real world. In consequence, following the traditional path of error handling by enumerating all possible faults is hard to nearly impossible. With our research efforts, we aim at a flexible but robust methodology for failure detection and system recovery for autonomous mobile robots. Hence, we try to extract concepts from biology, adapt them to the technical domain of robotics, and implement them for our robots.

II. Description

One fundamental building block of an adaptive biological immune system is the so called dendritic cell. These cells are the main initiators of adaptive immune reactions. They serve as pathogen detectors, messengers, but also as elicitor for various immune reactions. Dendritic cells pass through several life cycles. Immature cells just float within the system and collect pathogens, which indicate an intruder or the unnatural destruction of a cell. Having detected evidence for abnormal conditions dendritic cells undergo maturation, which makes them travel to hotspots in the lymphatic system. There they use the discovered pathogens to activate means of selfdefense, starting the immune reaction.

Our approach mimics the dendritic cells. New cells are born continuously, and are exposed to the robots state. They are also exposed to stress and threat signals, which in conjunction with the state variables drive their process of maturation. As each mature dendritic cell represents the association of state variables with threat signals, these cells can be used to reason about the robot's actual sanity.



III. Demonstration

To demonstrate the effectiveness and capabilities of our artificial immune system we will harm one innocent but lusty NAO. While the NAO roams the field a blow of fate (we) will blind him spontaneously, simulating a camera fault. We do this very gently, by slipping a black sack over his head, so no NAO will be harmed by our experiment. When vision is gone, the immune system starts to react to an unknown situation. There is no explicit coverage of a camera failure and resulting errors within our code. Nevertheless, the immune system detects the anomaly as the robots behaviors do not lead to expected results. A walk for examples should lead to changes in visual perception. However, due to the fault in the NAO's visual sub-system no changes occur. While the vision sub-system is malfunctioning, the number of mature dendritic cells signaling an insane robot state steadily grows within the NAO's immune system. We visualize this process on a hospital like "patient monitor". If the number of mature dendritic cells exceeds a certain amount (concentration within the subject's body) the NAO becomes aware of its illness. In our demonstration this will result in calls for help and in sitting down for safety reasons. Finally, we will provide salvation to the robot by removing the sack. The NAO than will instantly start to recover and stand up again.