CSE914 Research Challenges for High-Assurance Adaptive Systems in the Face of Uncertainty

CSE914 Class
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1 Artificial Life

The research challenges addressed during the discussion included:

1. Combining the methods of swarm-intelligence, evolutionary computing, and adaptive control;

2. Reducing uncertainty by improving the validation of adaptive systems;

3. Categorizing bio-mimetic (mimicking nature), evolutionary computation and adaptive-control systems by the sources of uncertainty they are best suited to handle; and

4. Designing a system that would be able to adapt in situations in which failure seems imminent.

2 Neural Control of Artificial Limbs

The research challenges regarding classification of electromyographic (EMG) signals discussed included:

1. Unpredictability in the need and timing for classifier re-training

2. Alternative remedies for “low trust” situations (e.g., how to reconfigure and/or replace sensors in a live system)

3. Handling uncertainty associated with use of EMG signals on other muscle groups (e.g., situations involving under or over-correction from missing limbs)

4. Accuracy and response time of pattern recognition

5. General trust of pattern recognition and online retraining (e.g., public trust of a reconfigurable autonomous vehicle)
3 Evolutionary Optimization

The research challenges abstracted from our discussions included:

1. The promotion of communication across disciplines so that differing orientations on the concepts of uncertainty can circulate.
2. Identify characteristics to understand the influence of uncertainty.
3. Locating and developing benchmark problems to better comprehend the uncertainty in the domains involved.
4. Visualization of the results and performance, so that an open community is maintained.

4 Task Planning Under Uncertainty

The research challenges addressed during the discussion included:

1. Applying the Spreading Activation Network to problems with uncertainty outside of task planning.
2. Identifying types of uncertainty the visualization represented in the system, as well as how effectively.
3. Overcoming the shortcomings in this method for use in high assurance adaptive system.
4. Optimization that could improve the practicality of applying this system to real time problems.

5 Theory and Practice in Dealing with Uncertainty

The research challenges addressed during the discussion included:

1. Reducing aleatory (environmental) uncertainty, for example via mitigation or by constraining the environment.
2. Leveraging various theoretical frameworks—probability theory, fuzzy theory, info-gap theory, and derived uncertainty theory—in the management of uncertainty for dynamically adaptive systems.
3. Identifying applications for which candidate theoretical frameworks are inappropriate or have limitations.
4. Identifying mitigation strategies for the human error in system design; specifically, identifying mitigation strategies for design errors in system components that are intended to manage uncertainty.
6 Uncertainty in Self-Adaptive Software Systems

The research challenges addressed during the discussion included:

1. Comparing different types of uncertainty and classifying them as reducible and irreducible uncertainty, as well as uncertainty due to variability or lack of knowledge.

2. Deciding on the sources of uncertainty that are most difficult to handle, such as uncertainty due to decentralization, human in the loop, and unmeasured or unmonitored uncertainty.

3. Examining the state-of-the-art methods in handling uncertainty and whether they would work in high-assurance systems (some methods require learning, while other might allow the performance to drop below a critical condition before mitigating uncertainty). Methods such as RELAX were considered very promising.

4. “New optimum” and optimizing a combination of worst case utility, expected utility, and best case utility in a weighed fashion.

7 Capturing heterogeneity in gene expression studies

The research challenges addressed during the discussion included:

1. How to extend the applicability of Surrogate Variable Analysis (SVA) or at least Singular Value Decomposition (SVD) to other fields and applications.

2. Biological data are usually huge. Until today, SVA has only been used to remove noise due to unmodeled factors from Microarray experiments. However, there is still a very promising possibility of using SVA with other high throughput biological experiments like Next Generation Sequencing. The hope is that with increasing amounts of biological data the accuracy of the results will increase.

3. Although it is apparent from this paper that such an approach can be useful in removing noise due to unknown and unpredictable sources. Is it possible to trace the original meaning of these sources according to the context? In other words, can these mathematical vectors causing the variation/noise be interpreted meaningfully? This study does not answer this question and the answer may need further research efforts.

4. Can SVA-like approaches be used in high-assurance adaptive systems? This is unlikely today as it is obvious that the false positive rate of the results is still relatively high, which is not acceptable in such systems. Can we overcome this limitation?