

Paper: Information Theoretic Anomaly Detection : A Space Shuttle Main Engine Application

Summary

This paper describes a method for detecting anomalies from sensor data. The focus is to detect anomalies from test burns of a space shuttle engine. The main contributions of this paper are a system wide approach that can analyze large amounts of data and detect issues that affect the overall system, but are too subtle to be detected by any single sensor measurement. The second contribution is a local method that can detect local failures that can only be detected by examining sensors that are measuring the same event in different ways. The conclusion of this paper is that both methods work for different types of anomaly detection. These methods can be used to reduce the analysis burden by experts as well as direct experts to the sensors that can better describe what the issue is.

General Rating

BAD, WEAK, FAIR, GOOD, EXCELLENT.

- a) Presentation/readability/organization: Good
- b) Problem definition: Excellent
- c) Originality: Excellent
- d) Significance, Usefulness: Excellent
- e) Technical soundness: Good
- f) Analysis, impact, conclusion: Excellent
- g) Background and references: Fair

Detailed Comments

- a) The presentation of the problem and proposed solution were well laid out. I was able to follow the paper clearly from its problem statement through to the analysis. The language used was not highly technical especially for the engine specifics. This made the paper easy to follow and I don't believe any pertinent information was left out for those interested in optimization and detection.
- b) The problem definition was excellent. This is an application paper. The problem was to detect anomalies in a less labor intensive way than was currently being done for engine testing. The challenges of testing were clearly discussed. Additional information on how experts detect failures may have better scoped how this problem is currently being dealt with.
- c) I thought the paper was original. I don't know much about rocket engine testing, but this seemed like a novel way to apply previous detection methods. The originality of the algorithms is unclear to me. It seems that many of the parts are well established methods, but the combination of them in this way is new and has never been applied to this domain problem.
- d) Along with the problem statement, the significance was also well explained. I could see the impact that this implementation could have on engine testing. Additional areas

where this approach would be useful was not made clear. However, since the focus was solving a specific problem, not discussing broader impacts is fine. More information on what additional testing needs to be completed in order to implement this method fully would have been useful.

- e) The technical soundness is hard to evaluate. The idea is simple (evaluating entropy). The paper does a good job explaining this process. However, no fundamental analysis is done on the technique to discuss the amount of error, noise, or other possible issue that might arise. Those limits may be well established, but it was not clear to me based on the references. The testing conducted clearly highlighted the algorithms abilities. I thought the three test sets were good choices given the limited availability of testing data. To give more validity to the approach, seeing a wider range of issues detected by the algorithm. The issues may have been easy cases, so as the number of failure modes increases, the detection abilities can be better understood.
- f) The analysis was good. For each of the test conditions, a failure mode is explained and how the detection algorithm succeeds or failed is also explained. The analysis helped demonstrate the strengths and weaknesses of the system and where it can be useful. The impact was discussed throughout and reiterated again in the discussion. The paper did end a little abruptly. There is no future work section which would have been helpful.
- g) The background on the problem was excellent. Background on entropy methods was also very thorough. The references fully supported the claims of the work.

Paper: **QUICR-learning: A coordinated multiagent learning algorithm**

Summary

The paper describes a new approach for coordinating multi-agent systems in tightly coupled domains. The authors present a new algorithm with an additional feature compared to a previous publication. The main contributions of this paper are to show the abilities of the algorithm to leverage current multiagent rewards as well as demonstrate the effectiveness in new domains. The conclusions of this paper are that the algorithm is capable of coordinating agents in multiple environments better than other methods. Additionally, to create effective coordination in a tightly coupled multi-agent setting, an effective reward that is sensitive to the agents and aligned with the system reward is necessary.

General Rating

BAD, WEAK, FAIR, GOOD, EXCELLENT.

- a) Presentation/readability/organization: Good
- b) Problem definition: Excellent
- c) Originality: Weak
- d) Significance, Usefulness: Good
- e) Technical soundness: Excellent
- f) Analysis, impact, conclusion: Good
- g) Background and references: Good

Comments

- a) The organization of this paper makes the content easy to follow. The paper flows sensibly from topic to topic and clearly explains challenges for the problem and how the algorithm deals with them. Having related work at the end was confusing. Having it earlier in the paper, like after the introduction, would have added weight to the impact of the paper and made it clearer in what other areas this work can be used.
- b) The problem definition was thorough. I understood all of the challenges for tightly coupled multiagent problems. The authors also spent ample time explaining why other approaches fail. The explanation of the test domains also provided me with good understanding of what difficulties the domains present and how those align with the goal of the algorithm.
- c) Because the algorithm had already been published in a previous paper, the purpose of this paper was not clear. I believe it was to highlight a new type of counterfactual that can be used. The key contribution statement was vague enough for me not to feel confident about what the paper was presenting. The comparison between the existing methods was thorough, but the contributions statements could have been more specific to better highlight challenges.
- d) The paper seems very significant. Shortcomings of other popular methods were clearly displayed and analyzed. Accordingly, this algorithm appears able to deal with the tight-coupling issue much more effectively than other approaches. There was also

discussion on where the algorithm could fail. Figure 1 and Figure 10 both highlight how the new reward structure can deviate from the global reward, and in what cases it remains fully aligned with the global reward.

- e) The technical information and analysis stepped through each part of the reward effectively. Care was taken to describe the meaning of each term in the reward equation as well as how it is calculated. This level of detail makes the method understandable as well as easy to recreate.
- f) The analysis was strong. It repeated many of the challenges observed in the pseudo-background section. The shortcomings of the other algorithms was demonstrated through testing. The impact of the reward structure was stated throughout the paper and was clear to me. The impact of this particular counterfactual was not clear to me. More space could have been devoted to understanding when to use the DL Q-learning vs. QUICR learning. The conclusion summarized the paper well. It concisely restated the problem, impact, and possible extensions of the work completed.
- g) I thought the background was very good. I understood the other algorithms very well as well as what the shortcomings were. The placement of the background section was surprising to me. It would have been more impactful and given the reader more general information if had been earlier. Even though it is at the end, the background section does not talk about how the work completed in this paper can be applied in those other areas. The references to other papers were plentiful and well placed. Any statement of fact was backed up by a reference, or multiple.