Root Cause Analysis of faults in the Environmental Control and Life Support System (ECLSS) and Heating, Ventilation, and Air Conditioning (HVAC) Systems

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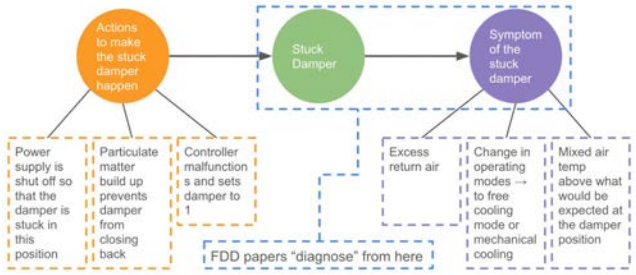
Introduction

Root cause analysis is a complex diagnosis task that aims to identify the correct cause for a particular fault as manifested by any number of symptoms. Simply classifying the fault (e.g., stuck air damper) gives little detail on how to fix the fault, however, identifying the root cause (e.g., there exists particulate matter buildup causing the stuck damper) can provide insight on how to properly eliminate the fault to either facility managers or onboard crew.



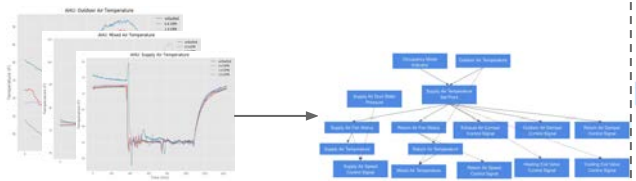
Research Motivation

Today, HVAC systems account for the largest portion (35%) of the total building energy consumption, and approximately 20% of that energy is wasted by poorly maintained, degraded, and faulty components [1,2].

When the ECLSS in the ISS experienced a leak the ground control team had to focus ~13 days of concerted efforts to isolate and plan recovery steps [3].

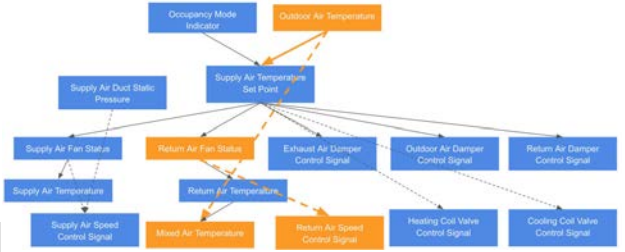
Proposed Vision

Using data-driven causal discovery algorithms, create a directed acyclic graph connecting the root cause, fault, and its symptoms into an easily understandable fault tree.

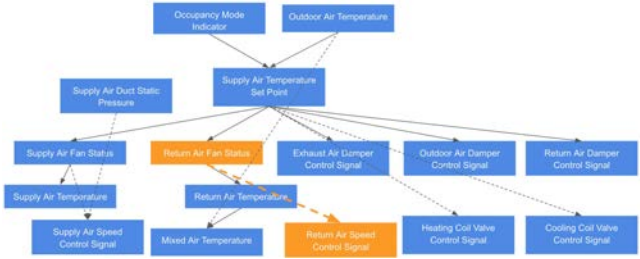


Proposed Vision Continued

Using anomaly detection, pinpoint all faulty variables to create a list of possible fault propagation paths.



Using causal inference, recommend the most likely root cause, fault, and symptoms on the fault tree



References:
[1] DOE, US. "Chapter 5: Increasing Efficiency of Building Systems and Technologies." *Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities* (2015): 143-181.
[2] Roth, Kurt W., et al. "The energy impact of faults in US commercial buildings." (2004).
[3] Dempsey, Robert C., ed. *The International Space Station: Operating an Outpost in the New Frontier*. Government Printing Office, 2017.