Data Life Cycle

MESMerizing Engineers

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1 Introduction

Rooms must be swept and closed off before a shot can begin. Once the doors are closed, the capacitor bays cannot be visually inspected without breaking the sweep and losing hours of work to re-sweep the area. Thus there is a need at the National Ignition Facility(NIF) to remotely monitor the conditions of the capacitor bay and laser bay without having a human breaking the sweep.

This is where our inspection robot comes in. The robot will serve two purposes. First, the robot will autonomously monitor the MESMs in the capacitor bay for any signs of failure or improper operation. Second, the robot can be remotely operated by a technician to manually inspect any specific issues that arise. A significant amount of data will be generated from this robot that we outline in this document. We will discuss the value of each type of data and how it impacts our project.

Note: We initially designed our robot to operate in the laser bay. However, the validity of our project will be tested in the capacitor bay. Going forward, we will limit the focus of this discussion to only the capacitor bays.

2 Overview

Our data cycle model is partitioned into the following four main steps:

1. Generation
2. Collection
3. Processing
4. Storage

Generation discusses where, when, and how the data itself is being generated. The collection phase is how we obtain that data, how much, how fast it's being collected, and how it's being represented. Processing explains how the raw data gets changed and the purpose for changing it. Storage is how we plan to store and archive any data as well as how long to retain it for.

There are three main types of data being analyzed: Visual information about the primary inspection targets, data from the robot's surroundings, and status information about the robot itself. Each of the three data types will be analyzed with this model. Figure 1 presents a high level block diagram of our data.

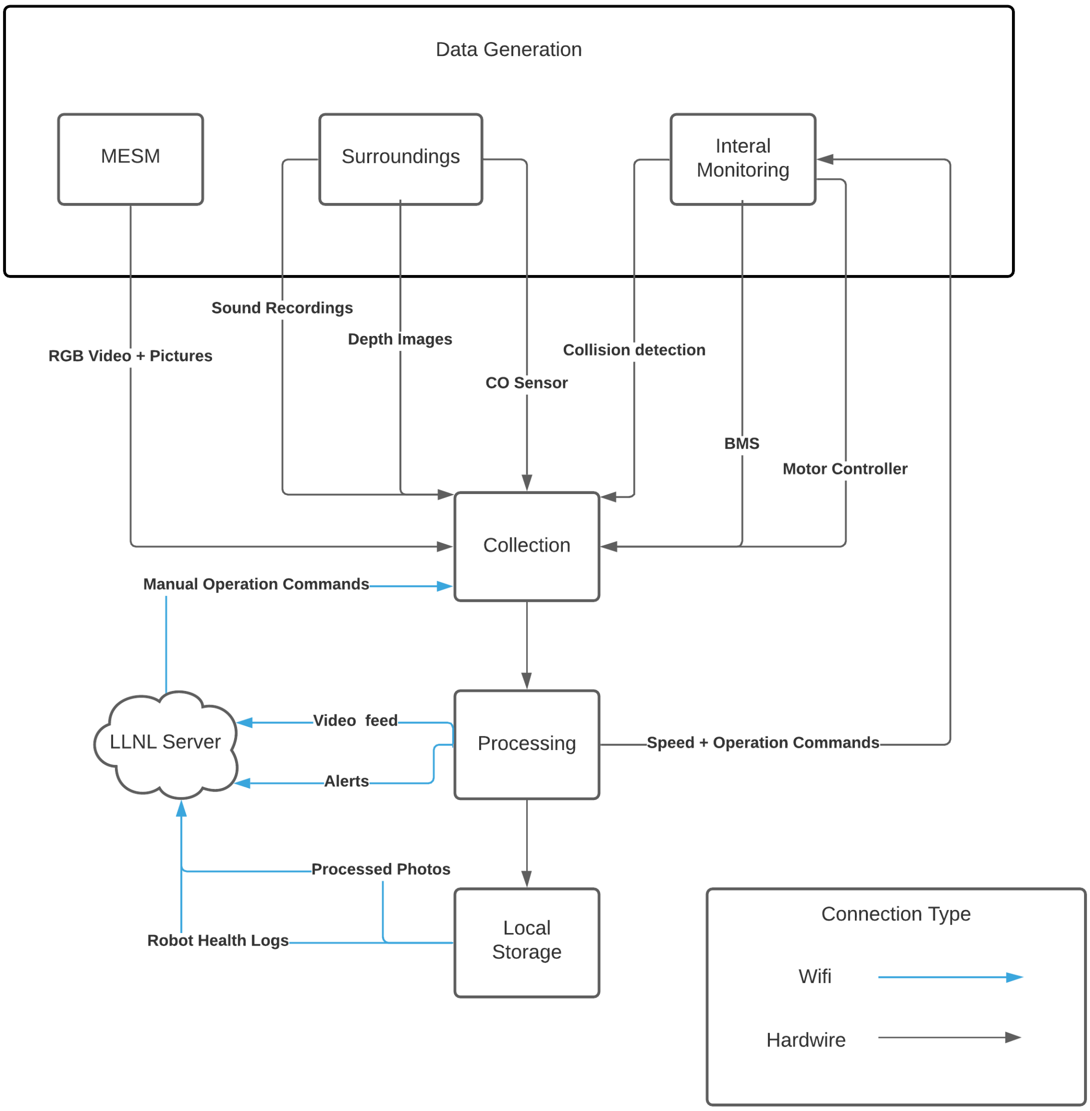

Figure 1: Block Diagram of the Data Cycle

3 MESMs

3.1 Generation

The MESMs are the primary concern for our robot. Relevant information includes:

- Status LEDs
- Heat being Generated
- Positions of Switches on the front panels
- Names of the specific MESMs

3.2 Collection

All of this information will be collected in the form of colored images and videos. The camera takes 8 megapixel images as needed. Video can be taken up to 1080p at 30fps. A thermal imaging camera will generate a heat map in the same frame as the color images.

3.3 Processing

Color and thermal images and video will go through basic tuning, like contrast and saturation, based on lighting and other conditions of the room. If being operated by a technician, a video feed will be encoded and sent to the operating room and decoded. Additional image tuning will be made available on the remote end.

An initial set of test images will be used to make an object recognition(OR) model to aid in the autonomous inspections. Any new images will be ran through this OR model and classifications will be made. The model will determine the following:

- MESM ID Number
- Operation mode (Normal, Need Verification, Damaged)
- On/Off status of Each LED
- Position of Each Switch
- Overheating

3.4 Storage

All images and video will be locally saved on a 1 TB NVME SSD. Both the processed and raw files will be preserved unless manually changed. The majority of this information is only relevant at the time of capture. Therefore, we propose that the default retention time for these images and videos be set at **2 weeks**. This gives technicians enough time to go over the footage while also reducing the amount of unnecessary data being stored. In the occurrence that the data reaches max capacity, the following protocols will be implemented:

- Images will contribute no more than 30% of the max capacity.
- Videos will contribute no more than 60% of the max capacity.

If either condition is not met, the robot will begin delete data chronologically in 10% intervals.

The images and footage will also be uploaded to the LLNL server upon completion of each routine inspection. We propose a retention time of **one month** to allow for more flexibility.

4 Surroundings

4.1 Generation

The surroundings category is composed of various readings from the robot's near surrounding that provide useful information in an indirect method. Types of important data include:

- Distances from the robot to its surroundings for navigation
- Smoke and CO in the air that could indicate a fire
- Sounds and noises from faulty fans and other equipment

4.2 Collection

The robot will be continuously taking infrared and stereo images from a pair of navigation cameras. The Intel Realsense T435i will generate 720p depth data at up to 90Hz. The Intel Realsense T265 will generate positional(pose) data at up to 262Hz .

Smoke will be detected through a carbon monoxide sensor. A specific sensor module has not been selected yet, but a current candidate will provide CO monitoring from 0 parts per million(ppm) to 1000ppm at 1Hz.

Sound will be picked up by a microphone. This feature has been recently requested. As such, we have not finalized the specific equipment for this task. this section will be updated when information becomes available.

4.3 Processing

The robot will take the 3-d depth data to stitch together a map of the room. This map will be reduced to two dimensions for faster processing. The pose data will be used to place the robot in the map and update it's location relative to the map. This map will be updated continuously to account for drift and dynamic changes to the environment. This information will also be used to send the appropriate movement commands in autonomous mode.

No modifications will be made to the CO sensor data. Appropriate ppm levels will be developed as needed. Alerts will be generated based on the raw readings and the set thresholds.

Sound recordings will be digitally filtered for specific high frequency sounds that could represent faulty fans. Alerts will be generated based on the detection of specific high frequencies

4.4 Storage

The map of the room will remain on the robot for the lifetime of operation in that room. The remaining data(CO, sound, position) provides no use after the images and video have been inspected.Therefore, this data will be retained with the same guidelines as specified in section 3.4 and summarized below:

- Local data will be retained for 2 weeks
- Server data will be retained for 1 month
- Data will be deleted chronologically to match the earliest recorded image and video

5 Internal Monitoring

5.1 Generation

To ensure proper operation of the robot, various components are continuously producing data to monitor the state of each component. Below is a list of that data:

- Status information (high level functioning information)
- Battery Management System (BMS)
  - Temperature
  - Cell Voltage Levels
  - Current Output
  - Power Output
  - Charge Cycles
- Motor Controllers
  - Temperature
  - Current Draw
  - Wheel Encoding
  - Absolute Rotation Count

5.2 Collection

Both the BMS and motor controllers will be connected via a CAN bus to relay this information to the central hardware controller and then sent to the main computer.

5.3 Processing

This data will be collected in its raw form for analysis. Proper thresholds will be set for each type of data and alerts will be generated if outside those thresholds.

5.4 Storage

The purpose of this health data is to monitor the state the robot and perform maintenance as needed. We believe it will be beneficial to have as much of this data as possible. The majority of this data is in text form that does not consume much space. We therefore propose the following retention times:

- Data will be stored locally until semi-annual inspections are performed
- Data will be stored on LLNL servers for the **lifetime** of the product.

As always, the retention time can be adjusted as needed.