Smart “PIG” (robotics) for Detecting Internal Damage and Environment Inside Pipes

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Background/Objectives

- Pipes transport water to each household, wastewater generated in each household to the wastewater treatment plant, and also more than 80% of the oil/gas and chemicals in United States and around the world.
- The health condition of a pipe is very important to the safety transportation of these important matters related to our daily life.
- To maintain the pipe in a good condition, smart PIGs are commonly used, which is one of the most high-tech inventions of pipe industry. The “smart PIGs” are used for pipe cleaning and dewatering, and more importantly for pipe health condition inspection.
- In this project, we developed a small smart “PIG” for inspecting pipe damages and corrosive environments inside a pipe using camera sensors on the smart “PIG” by optimizing the numbers of LED lights needed for the camera to detect correct images inside pipe, the locations of the camera, the types of camera to be used, the run speed of the robot, the size of the robot, the video image quality, and the color detection quality.
- In addition, this project will also develop a color-detection program to fully investigate pipe anomalies that occurred throughout our ongoing pipeage system, which was tested using a 10’ diameter pipe.

Figure 1 (a) Figure 1 (b) Figure 1 (c)

Methodology

- Based on literature review, each PIG consisted of a base steel body, gauge plates, sealing disks, and polyurethane rubber disks used for cleaning. A smart BIG was customly designed in the lab by remodeling a cleaning pig (BD-6 from In-Line Services LLC.) as shown in Figure 1 (a) with inspection Raspberry pi camera attached at the end (as shown in Figure 1 (b, c)) as inspection camera.
- Python was used to program the smart PIG to interface with the camera since it is easy to read, and write, and shorter, than other typical coding formats. Temporarily, a USB was used to store video and for later input with the color detection code.
- Known algorithms were used to detect color changes inside the pipes for three main colors including blue, red and yellow.
- A custom designed 3D printed casing was designed to host the camera and the Raspberry Pi and an extension board was used to power the unit using a lithium battery pack. Two LED lights were used to provide lights for detection of pipe damages.
- In the lab testing, color images were used to simulate damages and cracks inside the pipelines. Various images qualities were investigated to include the effects of practical image quality in practice, indicating that the camera can export good image quality if it’s stable.
- However, the movement of the PIG causes some vibration to the camera, which needs to be stabilized to work effectively. The casing had a whole proportionate to the camera towards the direct center so we could get the clearest view of the pipe.

Results

✓ Figure 2 (a) shows the code that recorded the video using Raspberry Pi camera, which is a program that automatically records video when we turn the Raspberry Pi on. The delay time is usually around 5-10 seconds before it can start recording. The program was able to run and create a video that lasted up to 60 seconds inside the USB.

✓ Figure 2 (b) shows the codes for color detection which can detect 3 main colors including red, blue, yellow from a video. First, it took in a pre-recorded video and used that to analyze the video frame by frame and, in the end, merged all those frames together to create a video that shows the color in the video. The image quality had to be good for this along with the poignancy of the color for the color detection code. In the boundaries, we can change the color to any other color by changing the RGB.

✓ Figures 2 (c, d) show the screenshot of the color in a black background in real and after detection. It was able to detect blue colors inside the pipe.

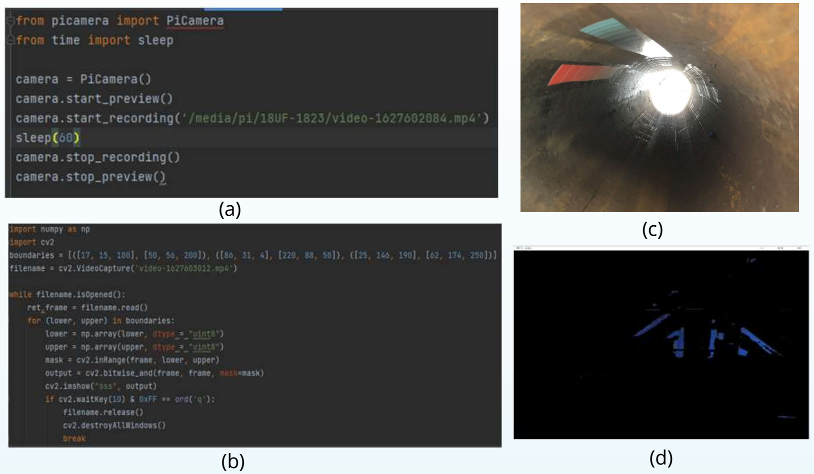

Figure 2 Codes and Color Detection inside Pipes

Conclusions and Future Works

- ✓ The designed smart PIG showed that it was able to clearly detect different colors placed throughout the pipe indicating the effectiveness of our developed smart PIG.
- ✓ However, there are still many persistent problems such as 1) improving the camera quality so that even under pressure and vibration, it is still able to take perfect videos; 2) the casing that contains Raspberry Pi board and camera was made of 3D printed materials so it might break under pressure (in water); 3) space did not seem adequate inside the casing; 4) the placement of camera was fixed which do not allow for easy adjustment, for larger sized pipes, it may not catch anomalies that our contraption was able to get in our relatively small 10” pipe.
- ✓ In future, Wifi connection is needed for remote detection.
- ✓ Improvements can also be made by changing the case into a steel casing or by putting the entire board inside the PIG. This would allow the camera to be mounted on the head of the pig.

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