James Carmichael & Peiyao Li
GPGN590
Team Term Project - Proposal
2022-02-17
Team Edgar Mine: Carmichael & Li; Project Proposal Write-up

The primary project, taking place at the Edgar Mines facility, aims to measure and monitor slug flow via Distributed Acoustic Sensing (DAS). DAS, a recent trending technology being used for pipeline quality evaluation. This technology offers continuous, real-time, and remote acquisition of data. DAS is also quick to mobilize and install. In this case, DAS is used along, as well as coiled about a pipe, whereby allowing the monitoring of strain-rate and track the response to the propagation of the slug flow. This type of flow is a common-occurrence/phenomena in multi-phase hydrocarbon production and transportation in both vertical, as well as inclined wellbores. Detection can prevent both unnecessary costs and allow the assessment of wellbore casing or pipeline integrity. This study potentially will reshape multiple disciplines and applications, from oil and gas pipelines, various facilities, to civil engineering infrastructure projects.

Fluid dynamics modeling is not always straight forward, there are many variables that impact the result, from: pipe diameter, inclination, curvature, material, any existing damage (dents or erosion), etc. So, by monitoring the movement of slug flow, the scientific community may be able to better constrain the aforementioned parameters. The movement of slug flow provides an opportunity to better understand multiphase fluid flow within a pipe; from a perspective of how the flow influences acoustical and thermally on DAS response. In general, the composition of the slug flow consists of two parts: 1) the larger bubble has been named the Taylor bubble and is on the onset of the slug flow, followed by 2) a liquid slug, which takes on the appearance of a bubble curtain. The slug flow, travels at one velocity (group velocity), however the subparts (Talyor Bubble and Liquid Slug) each travel at different velocities (phase velocity). Along a pipeline trajectory, if there is any change to any pipeline parameters, from a physics perspective, the velocities will change and can be recorded by a Distributed Fiber Optic Sensing (DFOS) system.

As for what we intend for class project and how it will bring value and both impact and help the research group(s) in Edgar Mines, is to build a mechanism whereby allowing the remote operation of the mines based experimental flow loop. The structure on site, fully mimics a real situation, a pipeline which is: curved, bent, inclined, buried, etc. Along this pipeline there exists control valves allowing the flow rate to be varied. There are also two flow meters, one for air and another for water. Also, along the loop there are multiple point-pressure and temperature measurements, as a reference for DAS response and slug flow movement. Due to the complexity of the daily operations on-site, strict facility time constraints, challenges to access the mine, economic impacts in terms of both travel-time and expense, and general safety concerns - there is a need for the ability for remote operation. Provided is a list of problems this instrumental solution will resolve:

1) Remote access allows alterations & testing even during nights, holidays or off-hours - when no personnel is on site or allowed within the Mines facility
2) Provides an important health & safety solution for when weather is hazardous:
    a. heavy snow – poor visibility
    b. icy roads
    c. extreme winds
3) Reduction/removal of two-way travel-time, from Mines campus or other location to access the Mine and back
4) Cost savings:
    a. Fuel costs
    b. Wear and tear on vehicles

The initial project testing consists first to run various tests within the confines of the geoscience maker-space lab. Next the mechanism will be tested within the PE lab where a similar flow loop apparatus is already in place. Once those previous tests have proven reliable and robust, we will then test the remote mechanism in the ideal site of the Edgar Mines.

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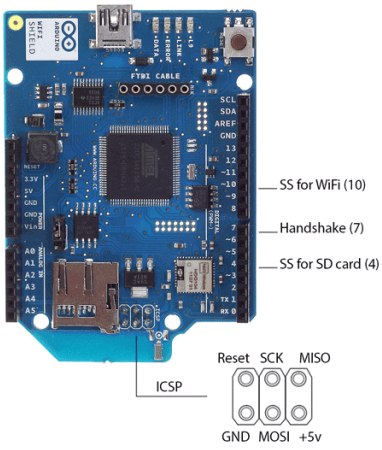
The baseline goal of the project is primarily to remotely tell a single Programmable Logic Controller (PLC) device, such as Arduino or RasberryPi or other, via commands sent over a cell-phone network or internet modem to mechanically turn a valve off and on, with some method of confirmation that the command took place. Additional goals will be added on with continued success, such as the control of multiple valves, independently or potentially simultaneously. As well as consider the usefulness and if needed, optional varying flow at any given valve, allowing different Bernoulli calculations for the fluid flow. Below is a general list of parts we believe we need at this time, disclaimer as we continue to begin to work on the mechanism we may find need of other components:

1) Programmable Logic Controller (PLC) board, possibly two: one for "base" remote ops and one for Mine-site
2) Servo Mechanisms: at least a single, still need to determine required amount of torque for valve interaction.
    a. Likely to expand upwards to 8-12 mechanisms,
    b. Optional variation: mechanisms that allow varying turning degree, rather than purely off or on, allowing varying flow
3) Shift Register: combined with a single or multiple, allowing the control of upwards of 10 servos while reducing pin usage on board(s)
4) Wifi and/or Cell – shield & possibly network card: cost TBD Wifi likely cheaper, but Cell could avoid loss of internet on site

Rough, baseline, *Design Sketch*:

Base of operations, likely on Mines campus, assuming WiFi connectivity:



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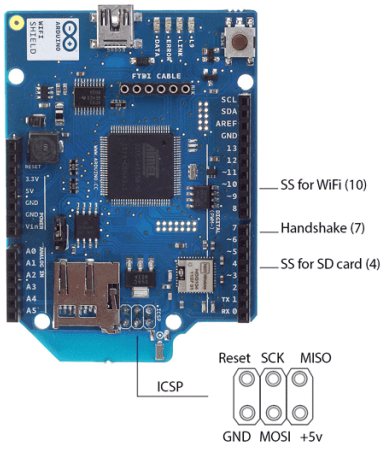
Edgar Mines site:



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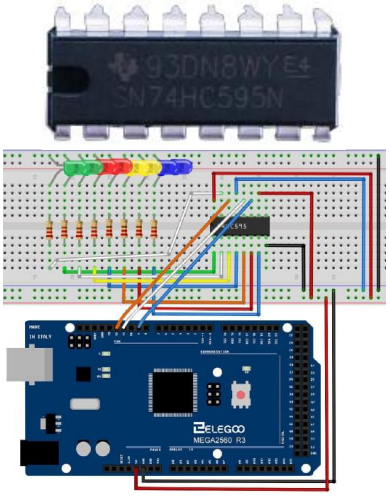

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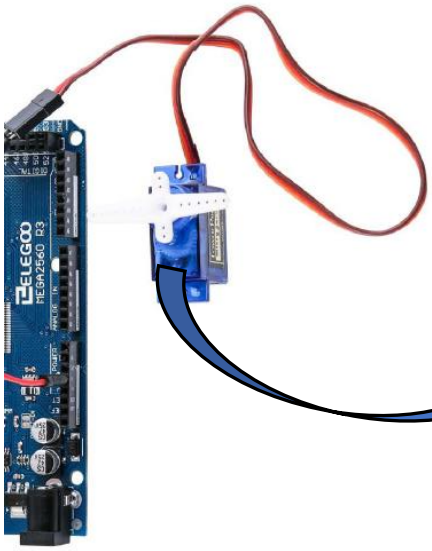

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Additional Design comments:

- Supplementary components: some type of weather/water proofing box/containment, which allows internal access to modify or fix but also can withstand the Mines on-site environment [high humidity and possible physical interaction ((bumps, knocks, shakes)]
- Servos will need additional fixtures, to ensure stability and independent motion allowing the turning of the valve and not just spin of the attached wires.