Importance of a PIG

I take some study cases in Indonesia. **I should add a more worldwide usage of localization importance.**

A PIG is a crucial part of a pipeline system, primarily a pipeline system with a lengthy distance. Large pipeline systems mainly use steel and ductile iron to distribute water supply to a sub-pipeline system. Steel and ductile iron are prone to corrosion due to not receiving any protection from material coating, or the coating layer fading over time due to the acidic traits of water in some of Indonesia's regions, such as Riau. Another example of pipeline failure is the fracture of pipes due to natural causes or errors made by construction workers, such as mistakes during ground excavation which might' lead to initially small fractures. These fractures might swell over time, leading to the failure of the pipeline water transport.

PIG is one of many systems that is usable to detect this kind of problem in a pipeline system. It's been used as a leakage detection based on Electromagnetic and acoustic signal detection. Electrical Signal usage for localization pros. This method is highly sensitive to changes in pipeline wall thickness, allowing for the early detection of potential issues. It is non-intrusive, inspections can be carried out without significant disruptions, ensuring continuous flow and operation. Its versatility makes it suitable for various pipeline materials, adding an additional layer of utility to inspections. Beyond merely detecting wall defects, the method can map deposits inside pipelines that might affect flow efficiency. This should bring benefit from real-time feedback, which facilitates swift and informed decisions late for the pipeline operators? The method should be cost-effective, given its minimal operational disruptions and capability for early detection.

The most important thing to be observed is that these early detections can contribute to enhanced safety by reducing risks, ensuring both environmental and operational security.

Other things such as cleaning a drinking water pipeline to ensure its debris (contamination from other things) free.

Source:

https://mediakaltim.com/warga-keluhkan-air-lumpur-hingga-rumah-retak-akibat-galian-pipa-gas-ini-jawaban-kontraktor/

https://kaltimpost.jawapos.com/balikpapan/03/05/2023/dampak-pengerjaan-proyek-pipa-gas-senipah-balikpapan-kerusakan-pipa-ptmb-bertambah

https://metro.tempo.co/read/1776117/dampak-pipa-pam-bocor-di-petamburan-rumah-warga-kebanjiran-air-kotor-dagangan-terendam

Another addition of why pipeline cleaning is important.

https://www.dailymail.co.uk/news/article-11690923/TikTok-trend-tourists-risking-Bali-Belly-drinking-tap-water-sparks-warning-Aussie-expat.html

https://en.tempo.co/read/1657151/over-exploitation-makes-jakarta-groundwater-contaminated-by-e-coli-from-septic-tanks

PIG Design

The PIG will be constructed of two parts, assume that the design is symmetrical. These two parts will be connected with a pin joint. The PIG parts are mostly de-attachable, which makes it a modular structure. This configuration makes the PIG easy to work around in case there is an improvement to the physical design. The problem that is needed to be solved is the placement of electronic parts in the PIG. As for now the plan is still to refine these parts which should start manufactured on the third/fourth week. The parts will be made with TPU PLA using 3D Printer in DPTA lab, PETG and ABS can also be used, but the LAB provides PLA filaments, so I'll use what's in the lab for now.

Speaking about the electrical part it's viable to place the electronic parts in the center piece of the 1st part. The electrode can be placed on the face of the 1st part. Need to consult/try to know whether the end of each part need a support so the joint wont bend when it is in a straight pipe.

I've been doing an offline survey to some building material stores in Groningen, it seems that there's no store in the Groningen that sells a transparent PVC/Acrylic tube. There's a big store called Praxis that I will visit soon, maybe they have it there.
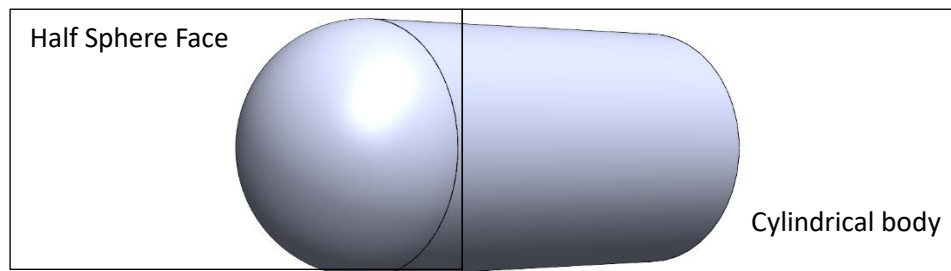

1st Part

2nd Part
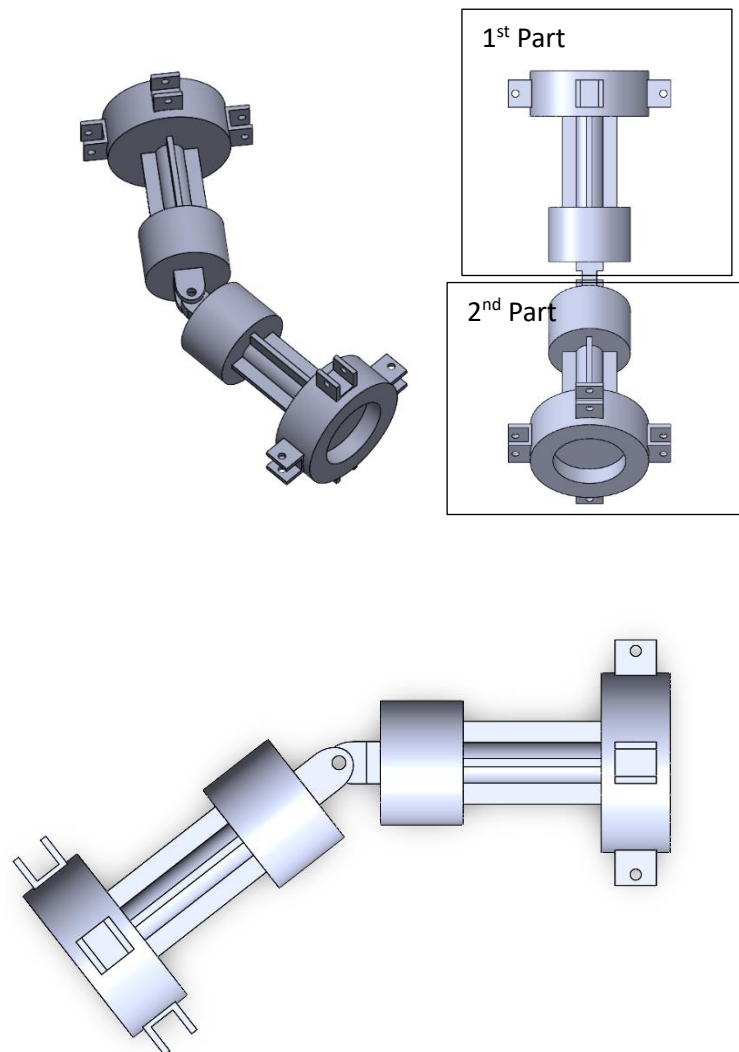
PIG Design 2

The initial model was to complex. No need to make a flexible joint of the PIG. Wheels also needed to be removed. Designed is then simplified with only a cylindrical body and a half sphere face. A half sphere face is chosen to have a simple shape with low Cd (Coefficient of drag).

Specification:
m $\approx$ 0.082 g, L $\approx$ 0.060 + 0.0235 m $\approx$ 0.0835 m, D $\approx$ 0.047 m
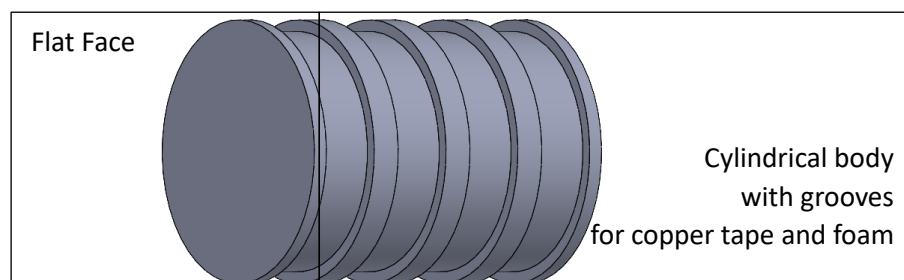

PIG Design 3

The second design was good, but it wasn't presentable (I suppose it is something explicit/inappropriate). So instead of using a half sphere face, the flat face of the cylinder is then used. This changes the $Cd \geq 1$.

Specification:
m $\approx$ 0.067 g, L $\approx$ 0.060 m, D $\approx$ 0.047 m

Dynamical model simulation is available at:

https://github.com/jcoiii/PIG-localization/tree/7551cbd6045f150d7a947e5ca46f1b4de634dc35/PIG_SIM
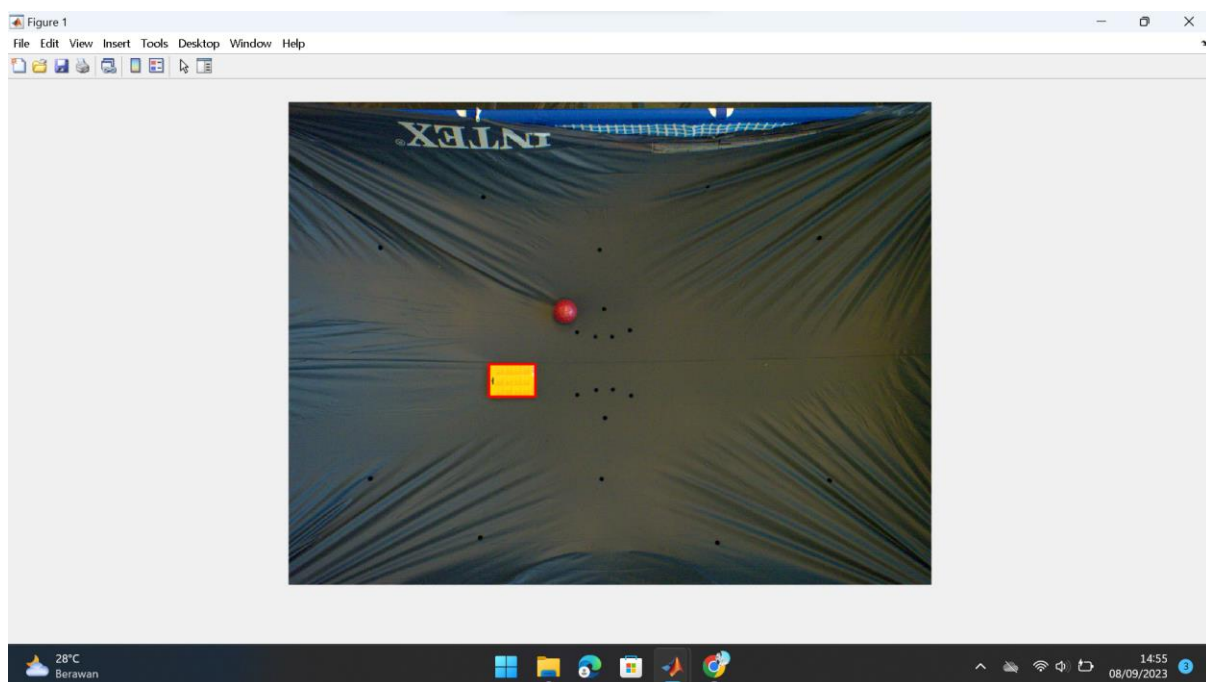
Tracking design through vision sensor

A Basler camera with unknown series and type is attached to the pool outer structure. It is connected to a PC through an Ethernet port. The PC used doesn't have any IDE to work with (either I didn't find it or there's none installed), what I find is that the camera used in the PC is working though ROS ecosystem, which I need to re-learn if I wanted to use it. Alternatively, I used my own PC to connect the ethernet port of the camera to interface it with MATLAB.

Since the camera is Gig-e based so it's possible to know the address of the connected device, so I'm able to interface it with MATLAB successfully after a few trials and errors. I made a MATLAB script, so it can track a defined object color and shape and bound in inside a red box, in this case a yellow rectangular object (this needed to be re-evaluated since the PIG shape won't be rectangular. Maybe making a reference shaped within the PIG can be done). The position of the pixel can also be printed in the workpsace variable tab. These pixels can be then converted to distance unit in the process.

One thing that need to be revised in the script is that the object needed to be always present in the frame, if the object goes outside of the frame and re-enter the frames, the script sends out an error.

A video of the object tracking is available in: https://github.com/jcoiii/PIG-localization/blob/0214a225035d1da8815e80daef069226cb27e8a3/Figure%201%202023-09-08%2014-44-15.mp4
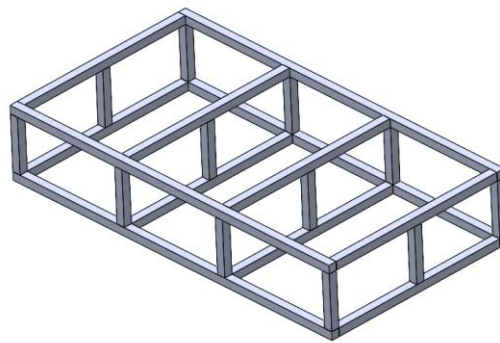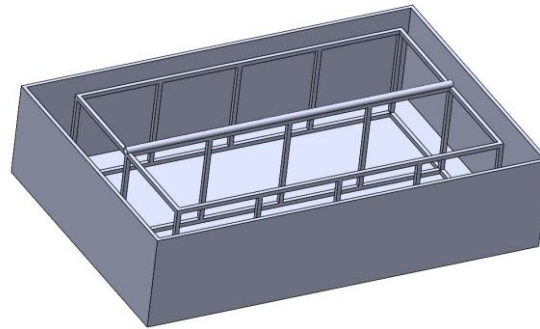
Pool Environment – Pipeline Platform truss

Pool size 3000 * 2000 * 700 mm

PIG system pipeline: OD 50, ID 47

The pipeline Platform truss structure is constructed with aluminium profile 4545 which makes the design to be modular. At first it is just used for a straight pipe, but the platform could also accommodate bend pipes
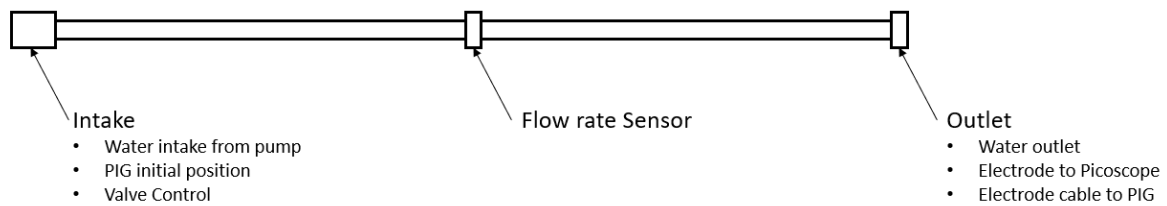
* Add a padding on the frames of the Piping structure, so it won't be damaging the pool environment.

As for the water flow in the pipe, a water pump will be used. A specification must first be defined. Initially I define that the PIG will move through the pipeline of 1.5m in 15 seconds, so we have:

$$Q = A \times V = \left(\pi \left(\frac{D^2}{4} \right) \right) \times \left(\frac{dist}{time} \right)$$

$$= 0.00174 \times 0.1 = 0.000174 \frac{m^3}{s}$$

The Flow rate (Q) is approximately 174 mL/s. This is the minimum value needed to transverse at 0.1m/s inside the pipe. Convert to L/h, Q = 626.4 L/h

Intake
- Water intake from pump
- PIG initial position
- Valve Control

Flow rate Sensor

Outlet
- Water outlet
- Electrode to Picoscope
- Electrode cable to PIG

Electronic items need to be used.

DC water Pump: https://www.amazon.nl/-/en/SWAWIS-Submersible-Dirty-Water-Fishing/dp/B09JF5PM8V/ref=sr_1_33?crid=2KZ72OAOS6HFD&keywords=dc%2Bpump&qid=1696468575&sprefix=dc%2Bpump%2Caps%2C70&sr=8-33&th=1

DC Driver: https://www.amazon.nl/-/en/BTS7960B-Double-Stepper-Driver-H-Bridge/dp/B09HGBM5D2/ref=sr_1_7?crid=3DTDHVD1UNQ7L&keywords=BTS7960&qid=1696468736&sprefix=bts7960%2Caps%2C64&sr=8-7

Arduino Due: owned.

Power Supply: https://www.amazon.nl/-/en/Vsnetwork-stabilized-transformer-switching-suitable/dp/B09R7SCTXL/ref=sr_1_8?crid=M0CUMBBMNO03&keywords=12v+power+supply+20a&qid=1696468904&sprefix=12v+power+supply+%2Caps%2C64&sr=8-8

Flow Rate Sensor: https://www.amazon.nl/-/en/Counter-Sensor-Control-Flowmeter-DC3-24V/dp/B091FPZC92/ref=sr_1_16?crid=2F41XZFPGVJ1B&keywords=Flow+meter&qid=1696488607&sprefix=flow+meter%2Caps%2C70&sr=8-16

Picoscope: Ruix's

Coaxial cables: Ruix's

Kalman Filter to estimate the position

The code is designed to simulate Kalman Filter to estimate the PIG position, using noisy impedance measurements. This is a hypothetical linear relationship between the position of the Pig and the electrical impedance measured within the system.

- Objective: The principal aim is to estimate the Pig's true position over time even when the measurements (in this case, electrical impedance) are contaminated with noise.

- Hypothetical Scenario: The code assumes a direct, linear relationship between the position of the PIG and measured impedance, described by coefficients 'a' and 'b'.

True positions of the Pig are synthetically created to simulate its movement through the pipe. From this, "true" impedance values ('Z_true') are computed, and then noisy measurements ('Z_meas') are simulated by adding random noise to 'Z_true

Kalman Filter applied iteratively, estimating the PIG's position at each timestep. It seeks to minimize the error in its position estimate by optimally combining the predicted position and the position implied by the new, noisy measurement. It weighs these based on their respective uncertainties, with the aim of mitigating the impact of measurement noise and providing a smoother, more reliable estimate of the true position.
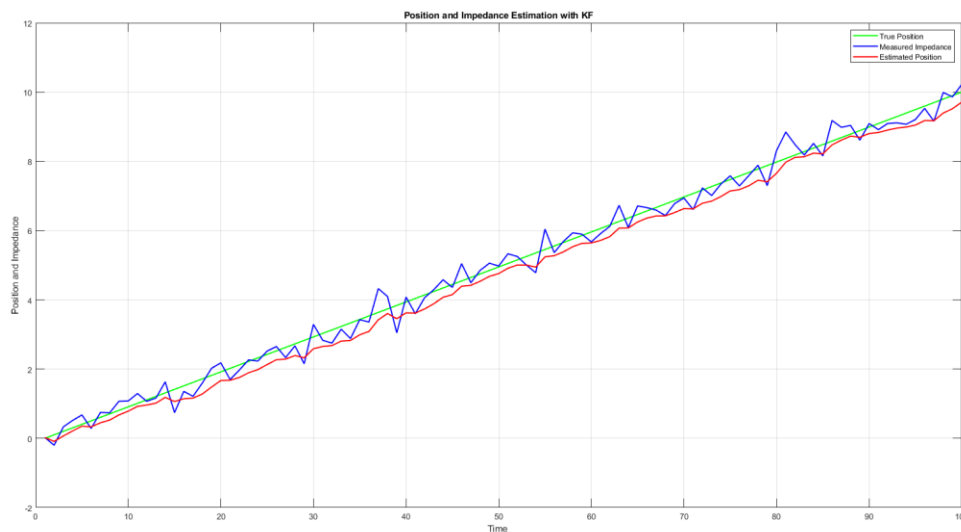
High Q: The filter will rely less on its own predictions and more on the measurements.

Low Q: The filter will trust its predictions more and weigh the measurements less.

High R: The filter will smooth out the measurements more, potentially neglecting abrupt real changes in the state.

Low R: The filter will be more sensitive to the measurements, possibly introducing more noise into the estimate.