IRLMS

Intelligent Real-time Land-movement Monitoring System

HKUST ISD 2021-2022 Final Year Project Group ALI Presents

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Advisor

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Abstract

This project focus on land-movement monitoring in construction site. Through conversation with Hong Kong construction company Paul Y. Engineering, the team found that the existing land-movement monitoring solution in the construction industry is frequently used yet inconvenient. So an Intelligent Real-Time Land-movement Monitoring System (IRLMS) is proposed. The team proposed and experiement on two solution: a Smart Inclinometer (SInc) method and a Meter In a Tube (MIT) method. Functional prototype is built for both method and the testing shows that both method performs equally good as traditional inclinometer while both have advantages in data manipulation and user interaction aspect. The IRLMS also gives the potential for building construction IoT system in the future.

Problem Definition

The team start the project with several conversations with Paul Y. Engineering. During the conversations, the team realize that there are many improvement that can be made in land-movement monitoring industry. As a result the team choose to focus on this area and asked more in details. During the interview and after some desk research, the team found several problems that is worth solving:

Data Manipulation

Normal inclinometer is operated by workers. The workers need to carry the inclinometer probe with them and go to work on site. The data is usually recorded manually on papers and transfer into an excel file later for data processing. while the data processing is done also by excel and output into a PDF file for future inspection. Also, human interaction with the machine leaves large uncertainty for the existence of human error.

Time and Frequency

The using method of normal inclinometer takes time. It takes two to three workers around 20-40 minutes to measure a inclinometer hole. And due to short of labor, the workers only measure one hole for around once to twice a month which this report argues that it is not frequent enough for land movement monitoring.


Workers installing the inclinometer tube


A set of inclinometer


Inclinometer Tube


Worker using a inclinometer

Existing Solution

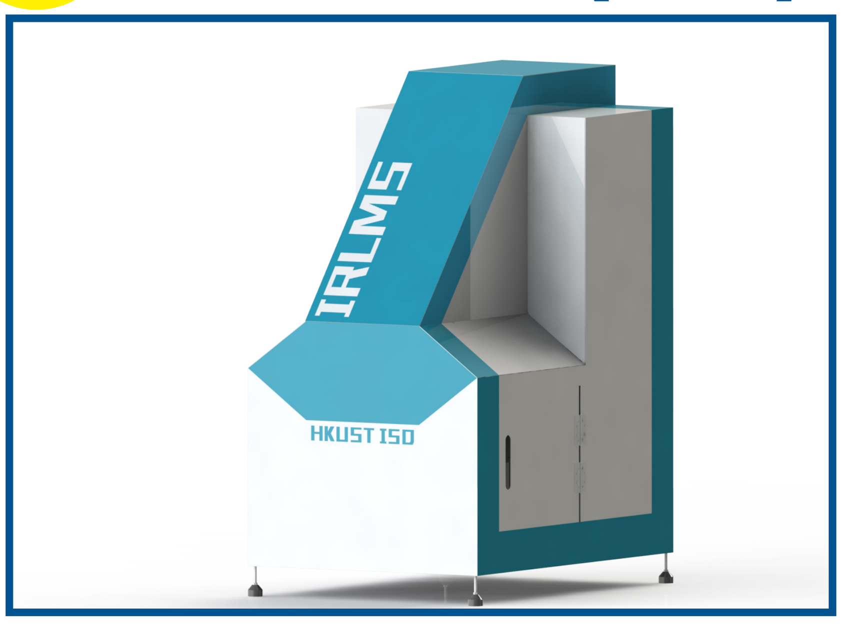
ShapeArray

The ShapeArray (SAA) is an array of rigid segments separated by joints that can move in any direction. MEMS gravity sensors placed in each segment measure the tilt in two directions. Processors transform each joint's position (e.g. X, Y, Z) to produce the change of shape of the whole tube.

C17-PRO Vertical Digital Inclinometer System is an inclinometer system integrated with an information system. The advantages include automatic data processing, automatic data uploading, and it can perfectly fit in the current system. However, it still requires a human worker to operate, so it is hard to achieve real-time monitoring.


Digital Inclinometer

Smart Inclinometer (SInc)

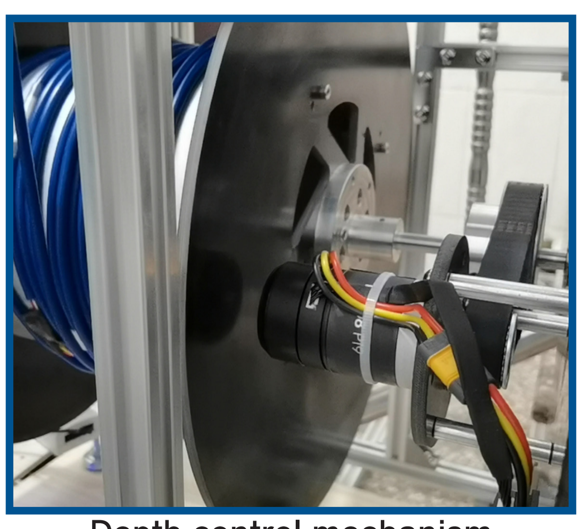


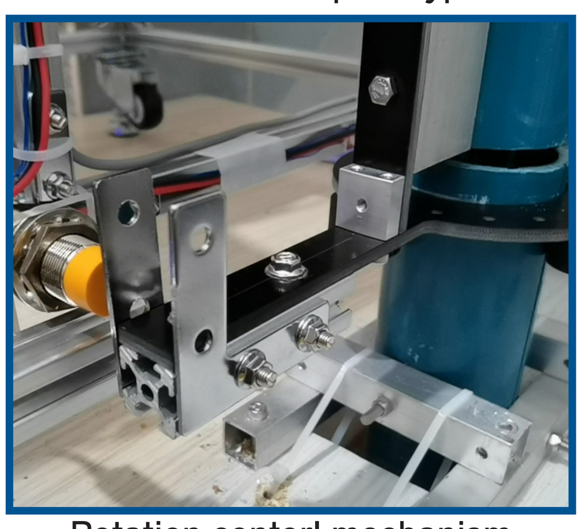
Description

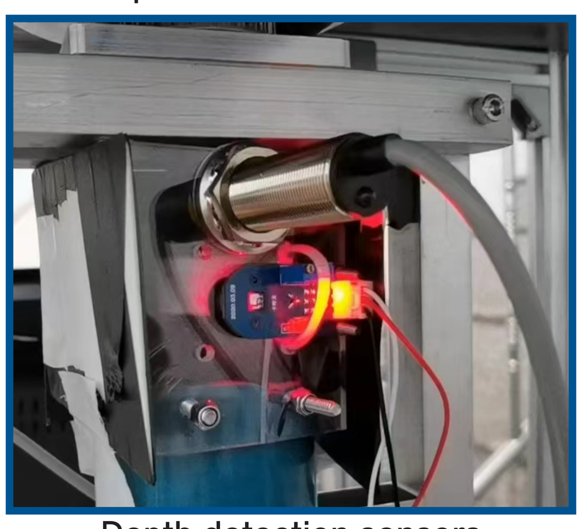
The smart inclinometer is a device put on top of each inclinometer tube. The device performs the works of a construction worker but fully automatically and more frequently. Smart Inclinometer will enter the working stage after every waiting period. At a working stage, it will put the inclinometer probe through the tube to collect data. The data will be processed and sent to the cloud for processing, visualization, and alert. Several Smart Inclinometers at different tubes and different sites form a network system. The workers can access the processed and visualized data of the whole system directly online and download the generated reports if needed. The Smart Inclinometer also has a human interaction interface for maintenance needs and special activities. Our prototype is fully functional and our experiment shows that the Smart Inclinometer performed equally to the traditional inclinometer but better in measuring frequency, data manipulation, and user interaction.

Prototype

Exterior of the prototype


Depth control mechanism

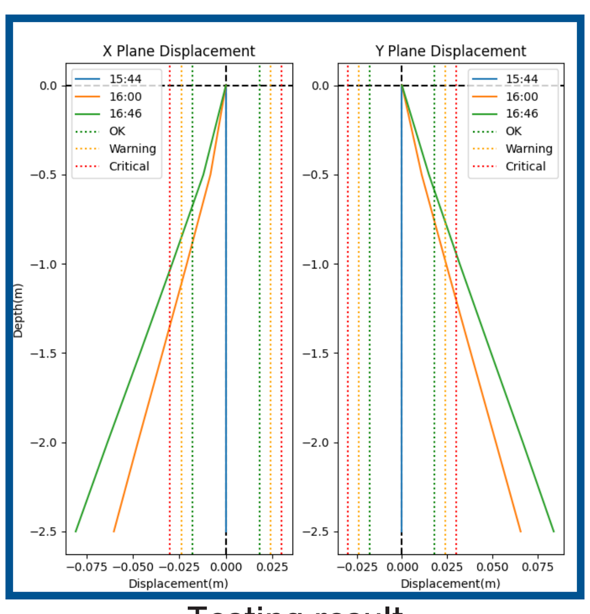

Rotation contorl mechanism


Depth detection sensors

Testing

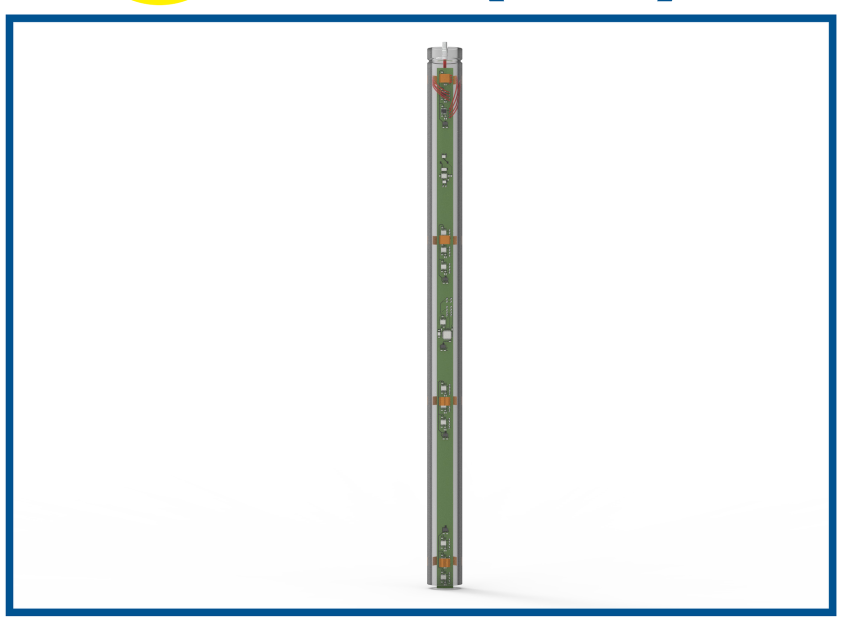
Due to limited resource caused by the pandemic, the testing is done using ropes and band tape. The testing tried to simulate the process of a land-movement towards a certain direction. The actual data collected compared to expected data has an 12.25% and 7.80% error which is acceptable under rough testing condition.


Testing environment



Testing result

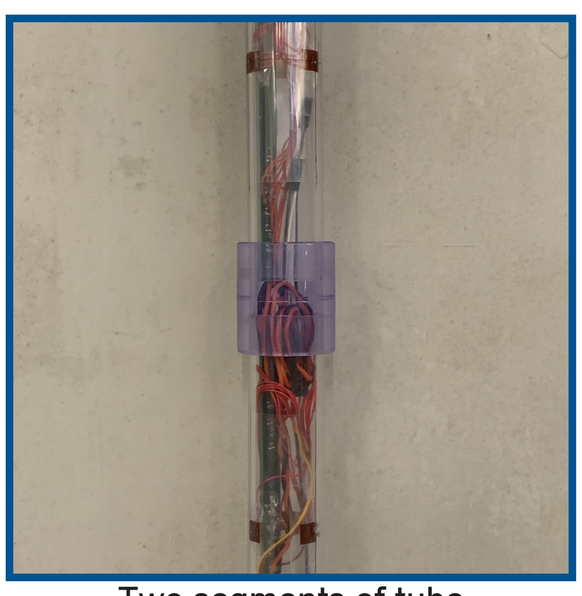
Meter In A Tube (MIT)

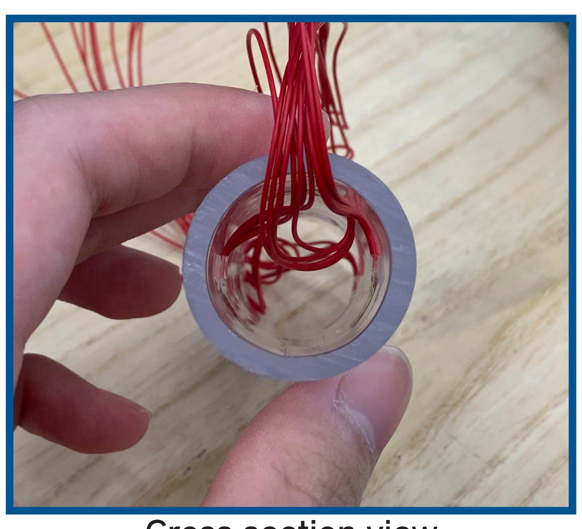


Description

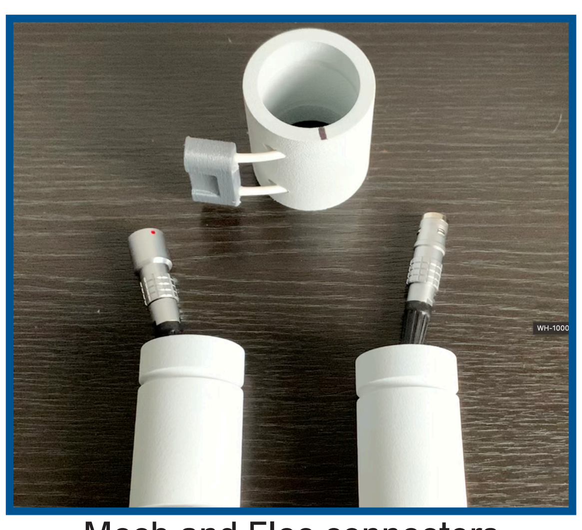
Meter In a Tube (MIT) is a device that reduces the number of total parts required by integrating the sensor with the tube. This eliminates the step of inserting a separate sensor into the tube and will still be useable when the tube is bent sharply since there are no moving parts. The sensors used are called strain gauges and they are adhered to the inner surface of the tube. There are 3 sensors along the circumference of the tube and 4 sets of these triplets along the 1-meter segment. Each segment is connected mechanically with a one-step connector and electrically with an aviator plug. After collecting data from these sensors, an algorithm will convert the collected data into a digital curve that reflects the shape of the actual tube.

Prototype


Two segments of tube

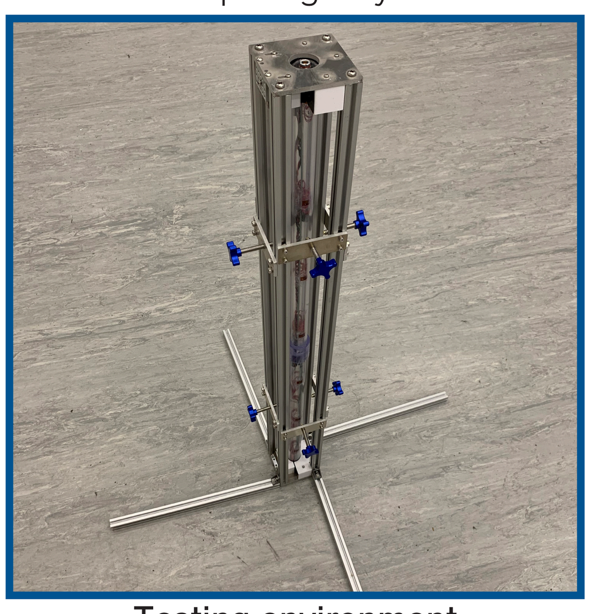

Cross section view


Two segments of tube


Mech and Elec connectors

Testing

A jig was created which would allow pushers to be installed in any location. This enables us to install pushers in different locations and bend the tube in different shapes. Testing results show that we are able to physically bend the tube in any direction and shape and still be able to see the same shape digitally in real-time.


Testing environment


Testing result

Conclusion

This project proposed two solutions targeting on intelligent real-time land-movement monitoring. The team start from defining the problem by interview and desk research. The topic of land-movement monitoring is chosen, and the team focus on making land-movement monitoring process real-time and user friendly. After generating the idea, functioning prototypes are built and tests and experiments are made. Though there can be improvement, this document argues that the proposed solution met the expectation of the team. Both method gives good testing result and answer to the problem statement. The team hope that this method can be implemented in field and improved in the future and better monitoring can be done to make construction safer and more convenient.

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