STAND-ALONE GEOPHONE MONITORING SYSTEM FOR EARTHEN LEVEES

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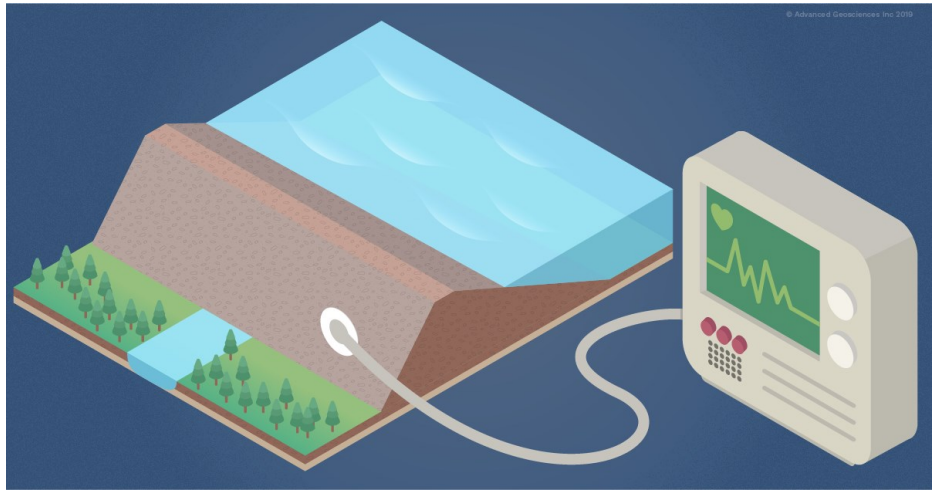

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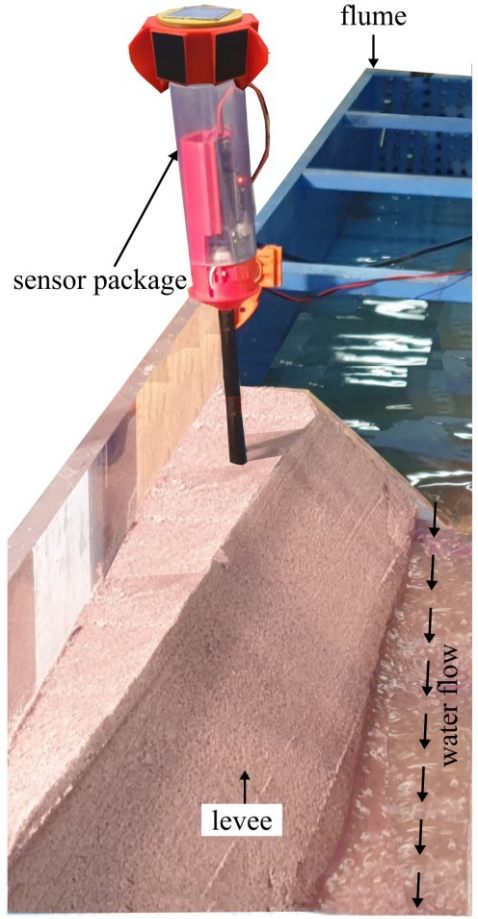

INTRODUCTION

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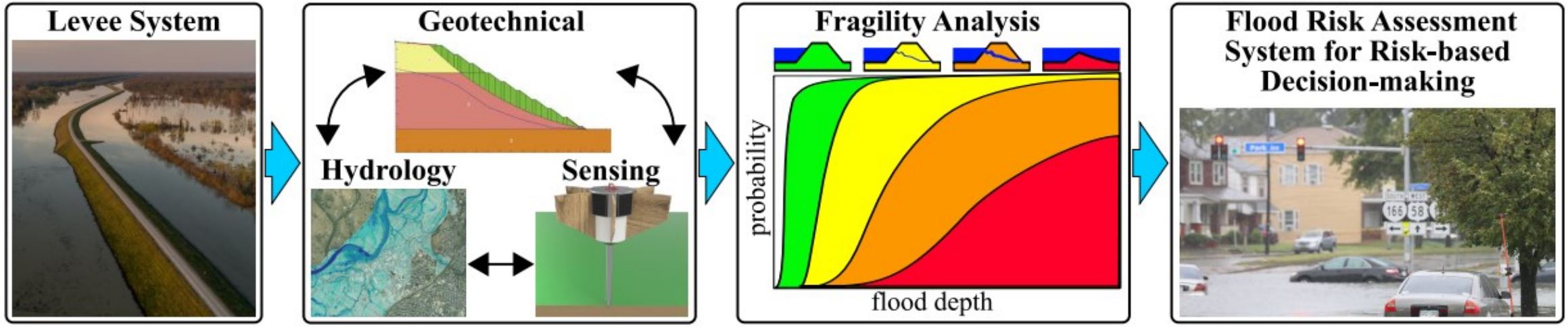
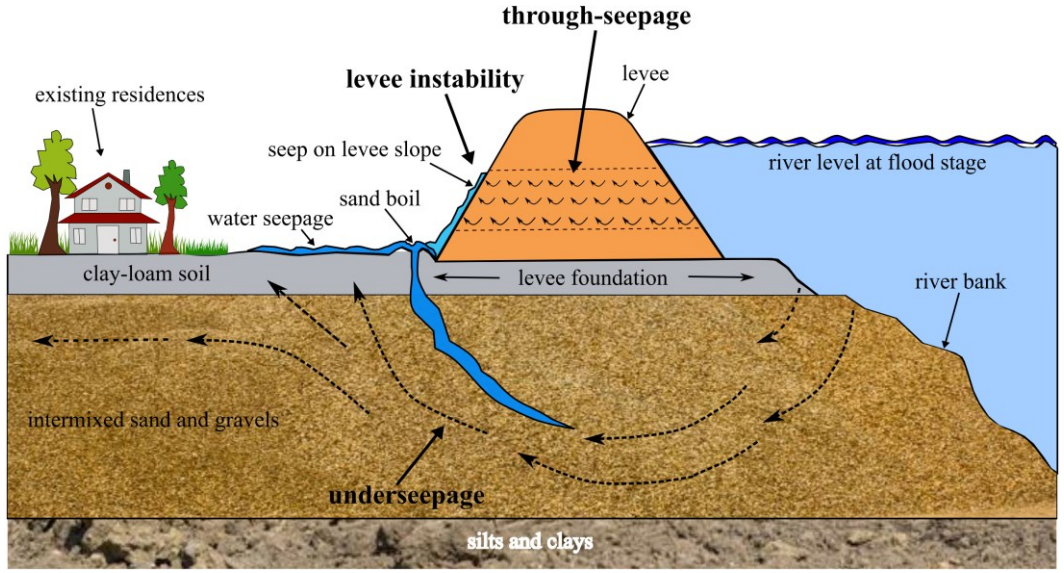
RISK ASSESSMENT OF LEVEE BREACH

- This work is part of a larger effort to develop a data-driven fragility framework for risk assessment of levee breach.
- This presentation will focus on preliminary results obtained using a UAV-deployable sensor package for monitoring levees.
- This work in being done in close collaboration with experts in data-driven risk assessment, geo-technical, and hydrology.



LEVEE

- A dry levee works by absorbing and slowing down the water until river level drops.
- Levees are made mostly of
  - compacted dirt,
  - not concrete or metal,
  - are permeable.
- Water will seep through or under a levee given enough time.



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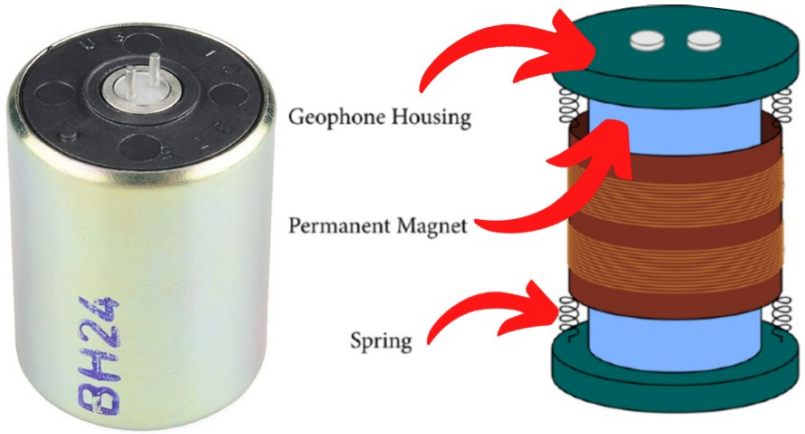
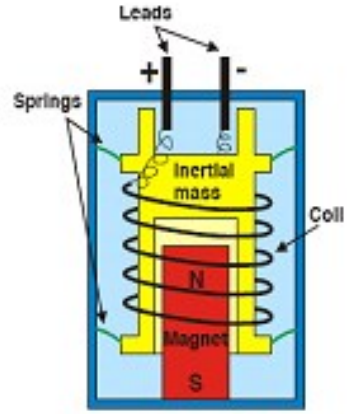
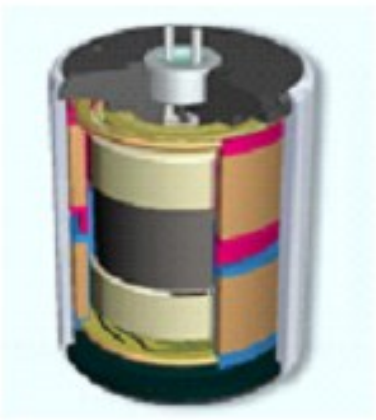
GEOPHONE-BASED MONITORING

- Geophones are devices that generate electric signals proportional to the particle velocity in a sound wave.
- Geophones can also be used to measure
  - used to measure sound waves propagating through the earth
  - particle velocity in underwater sound waves
- The name geophone is derived from the Greek word's “geo” meaning earth and “phone” meaning sound.



https://core-electronics.com.au/media/wysiwyg/tutorials/Tim/Geophone-and-Raspberry-Pi/Fixxxxx_Inside_and_outside.jpg





https://dosits.org/galleries/technology-gallery/basic-technology/geophone/

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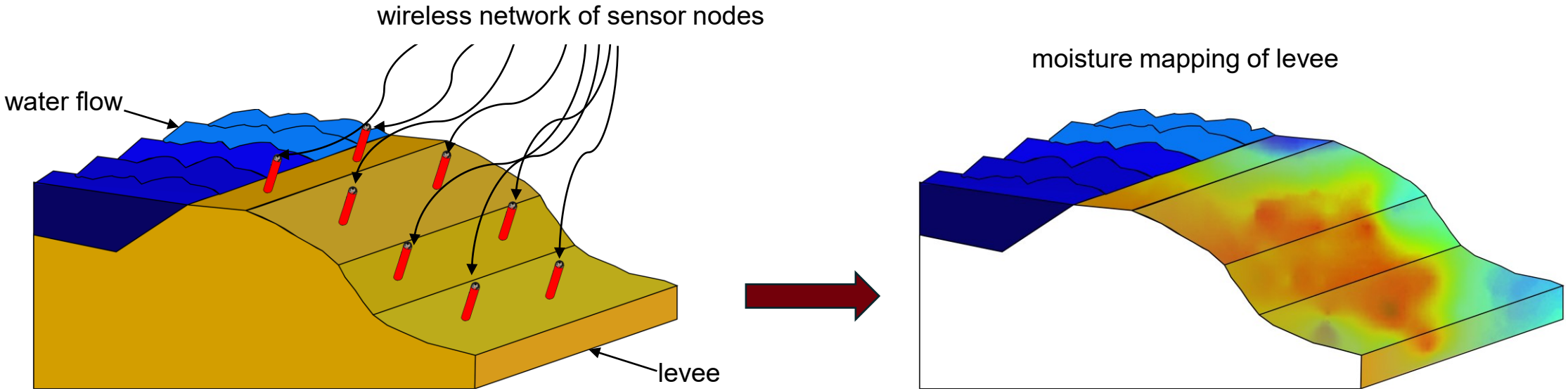
CONDUCTIVITY-BASED MONITORING

- A network of sensors, as well as the possibility of using a wireless communication system to send data directly to the user.



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METHODOLOGY

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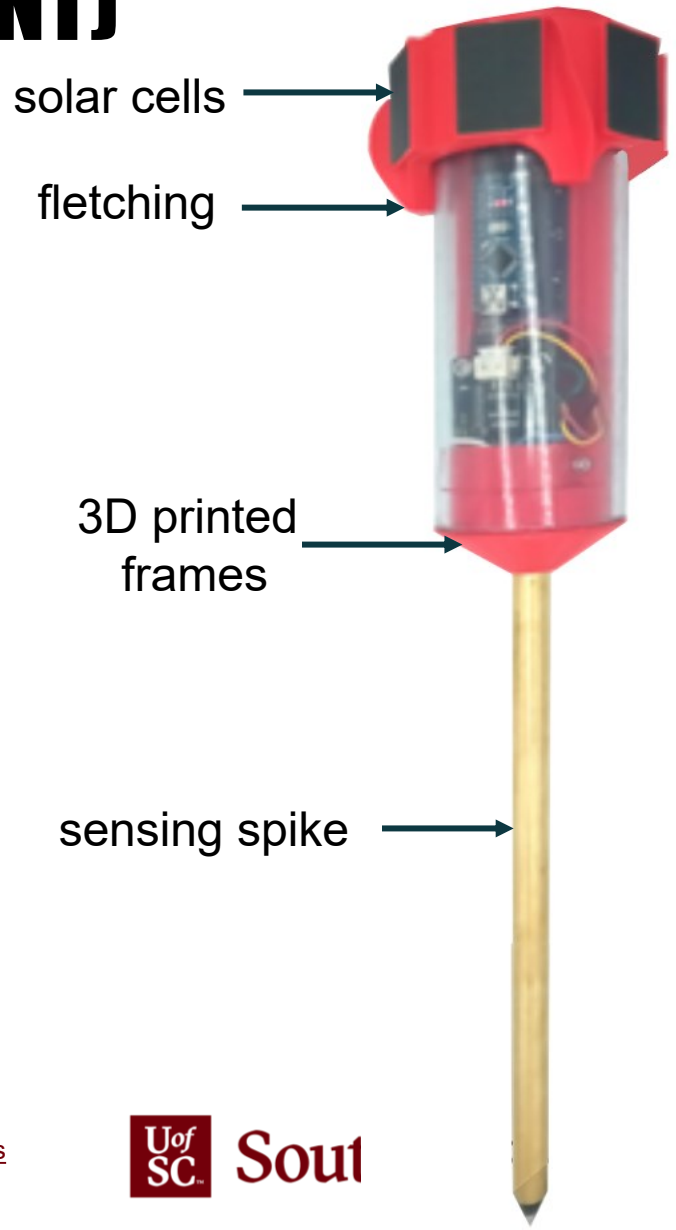
SENSOR PACKAGE (HARDWARE DEVELOPMENT)

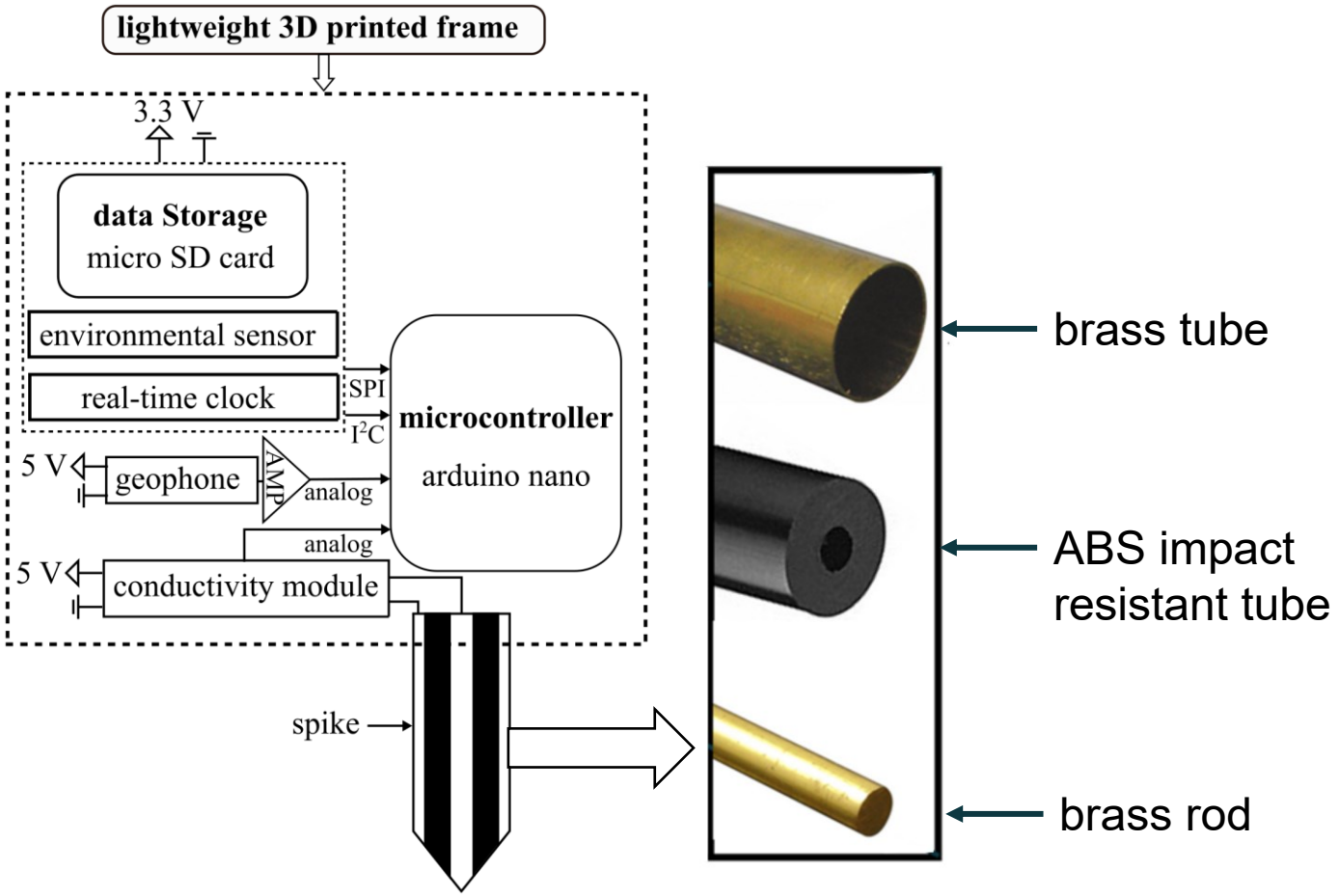
- Contribution's:
  - The first open-source stand-alone geophone system developed
  - The sensor's performance during laboratory-scale earthen levee failure experiments.
  - The advantages and limitations of the designed sensor package as a single node of detection rather than a network.
  - The designs for the smart penetrometer are available through a public repository released under the creative commons Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) licenses.[1]
- Sensor package is
  - fitted with a 3D-printed frames
  - six solar cells configured to aid in load sharing during sunny conditions
  - helical fletching design to induce rotational stability during free fall



[1] https://github.com/ARTS-Laboratory/Smart-Penetrometers-with-Edge-Computing-and-Intelligent-Embedded-Systems

SENSOR PACKAGE (HARDWARE DEVELOPMENT)

- The spike is designed to have two conducting surfaces
  - an outer tube
  - an inner rod
  - separated by an insulating ABS plastic tube.



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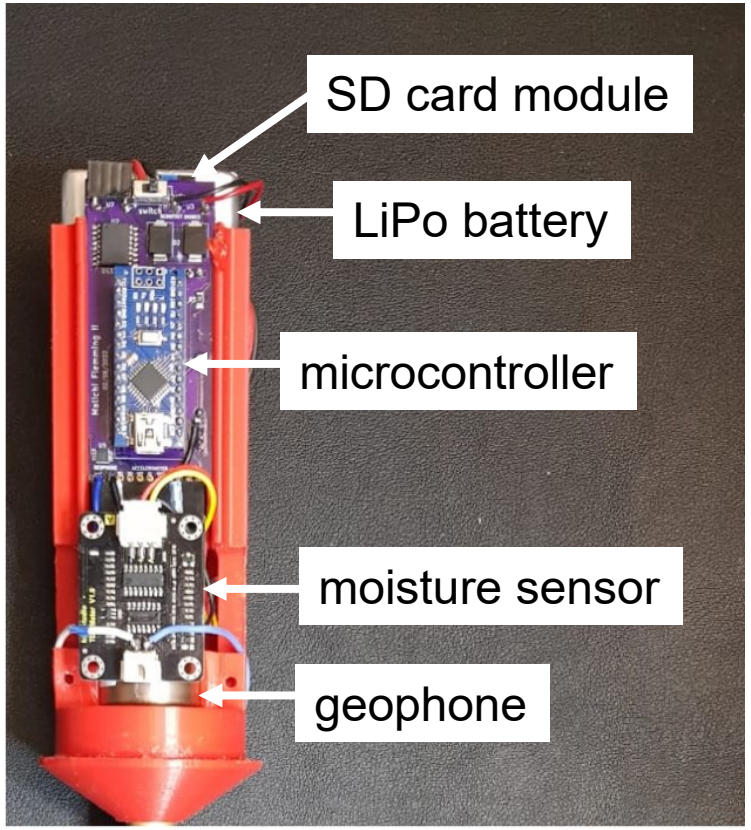
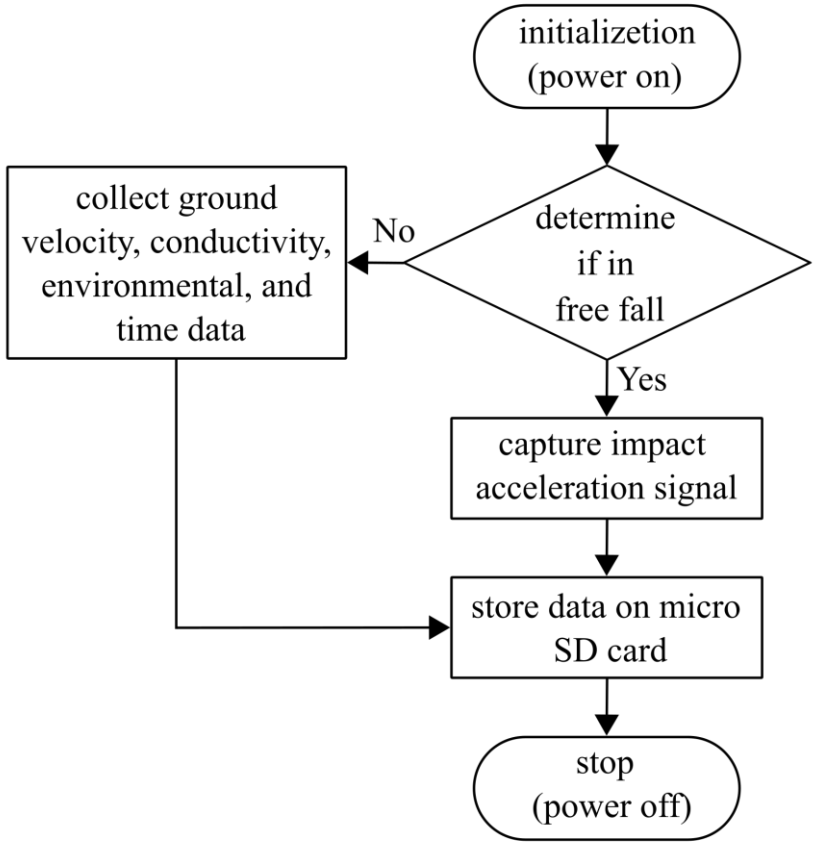
SENSOR PACKAGE (ELECTRONICS)

- Lithium polymer batteries are for their high-power density and desirable recharging properties.
- An Arduino nano microcontroller is utilized as the core processor of the package for its desirable footprint.
- An environmental sensing module is utilized to measure air pressure, humidity, and ambient temperature.
- A sensitive geophone to detect ground velocity during the deployment period.
- A Micro SD card module is to save data on device.



SENSOR PACKAGE (FLOW CHART)

- The package is designed to detect once it is in free fall so that the initial impact with the ground is recorded using the accelerometer on board.
- Once the package is secured on the ground, the various sensors on board are initialized where environmental parameters, ground velocity, and moisture are recorded periodically
- Data is stored on board the package until retrieval on an SD card to prevent any loss.



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EXPERIMENTAL SETUP

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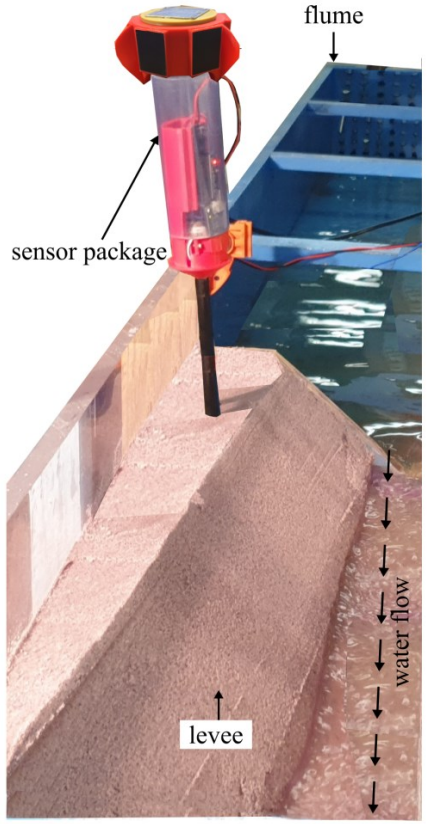
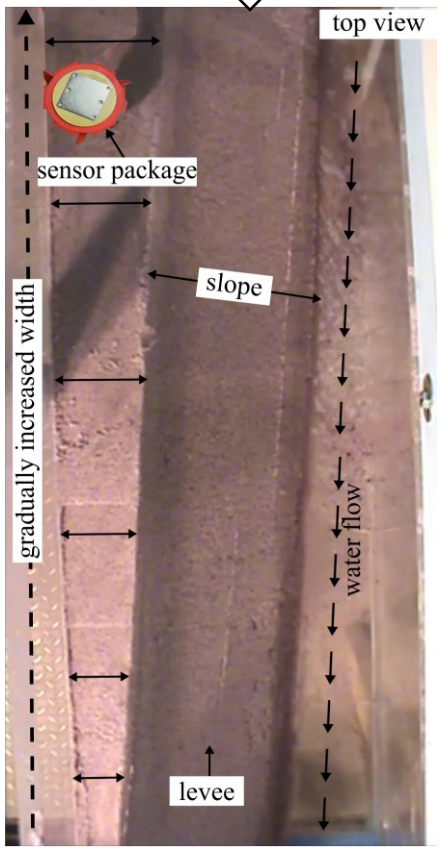
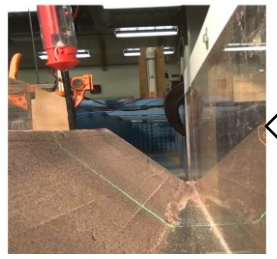
SENSOR PACKAGE LEVEE FAILURE TEST

top view

experimental setup

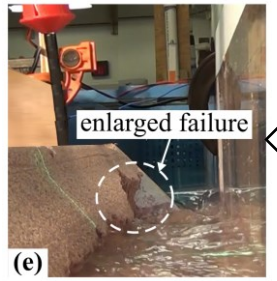






no water flow

limited water flow



high water flow

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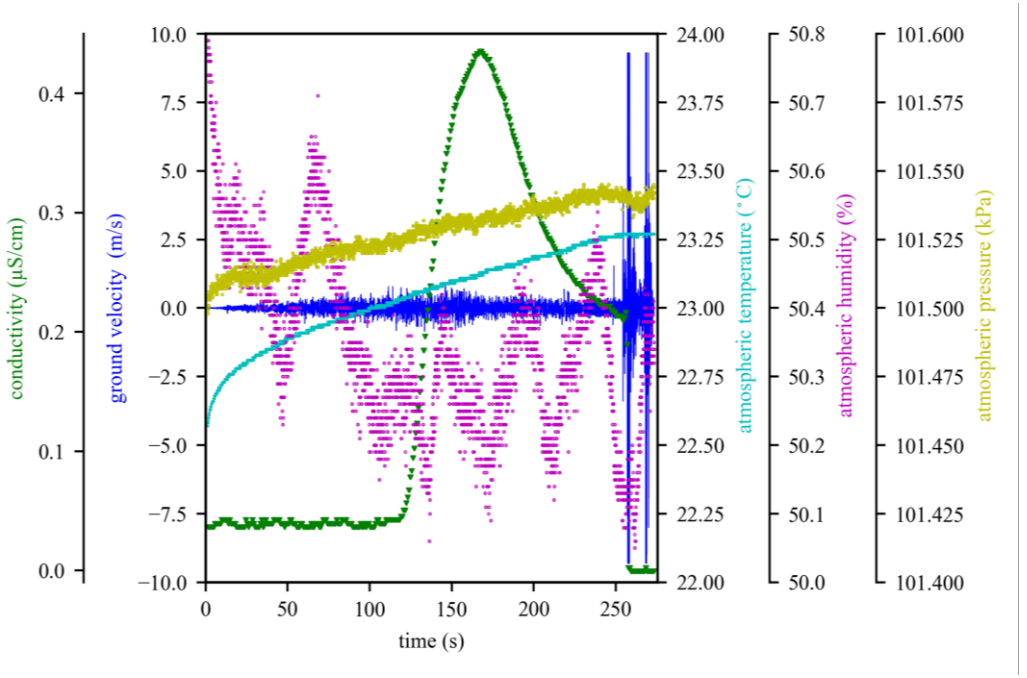
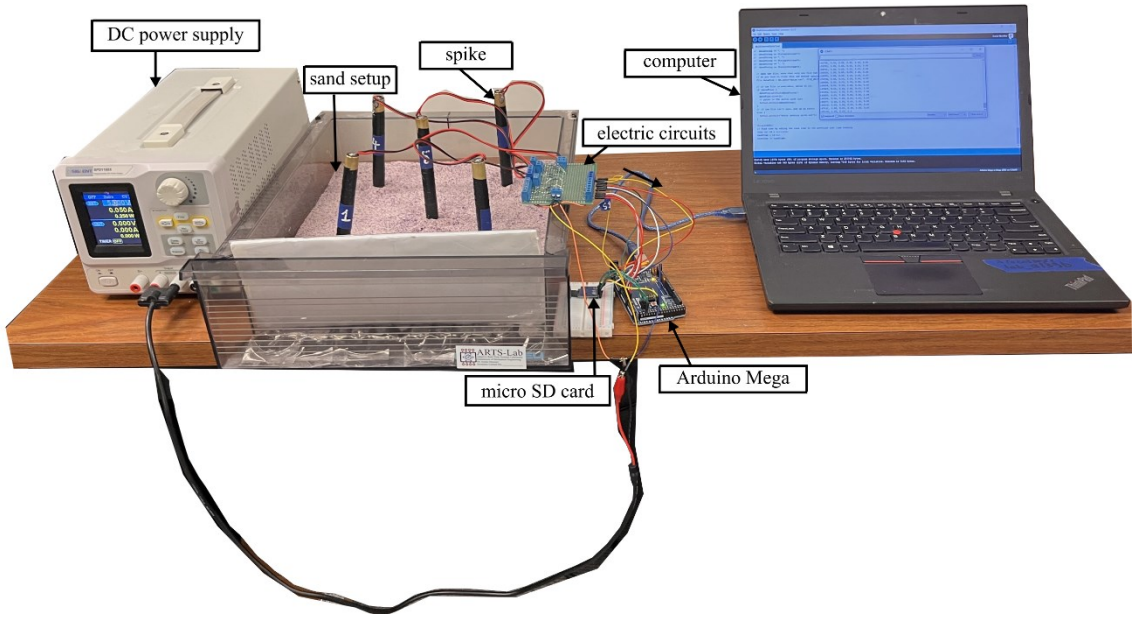
SENSOR PACKAGE LEVEE TEST

LEVEE TEST RESULTS AND DISCUSSION

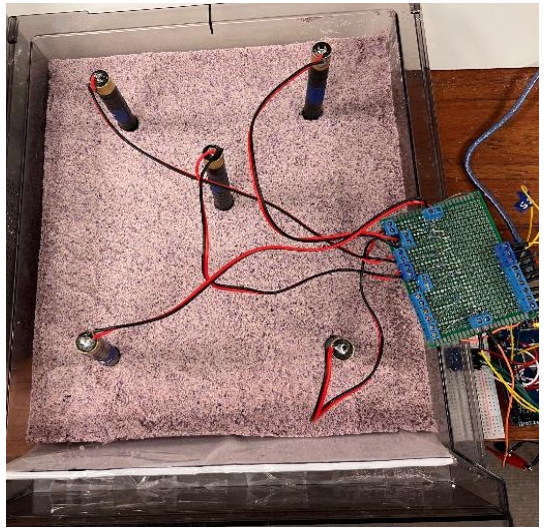
- A significant change of conductivity around 0.4 μS/cm is noticed at approximately 140 s which is due to the increased level of water flow.
- A sudden drop in conductivity is observed at 260 seconds which may be attributed to the formation of large failure and air pockets underneath the surface.
- Ground velocity reveal that until a significant failure occurs at roughly 240 seconds, the geophone returns steady results that are ± 2.5 m/s.
- A velocity of close to ± 9 m/s is measured at the large levee failure around 250 s.



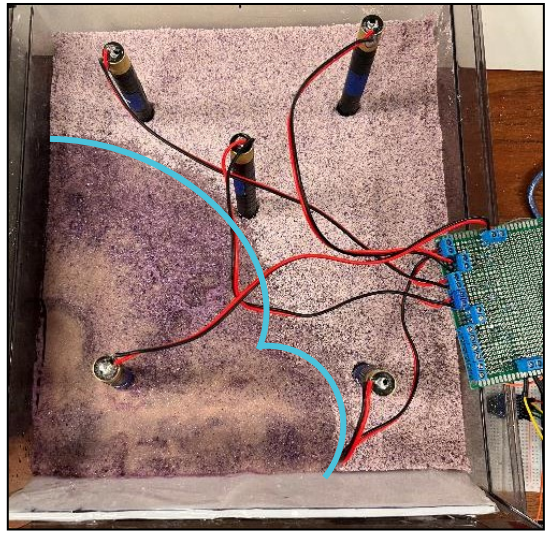
EXPERIMENTAL WORK (CONDUCTIVITY MAPPING)



Experimental setup for moisture test



Dry sand



Moisture propagating through sand

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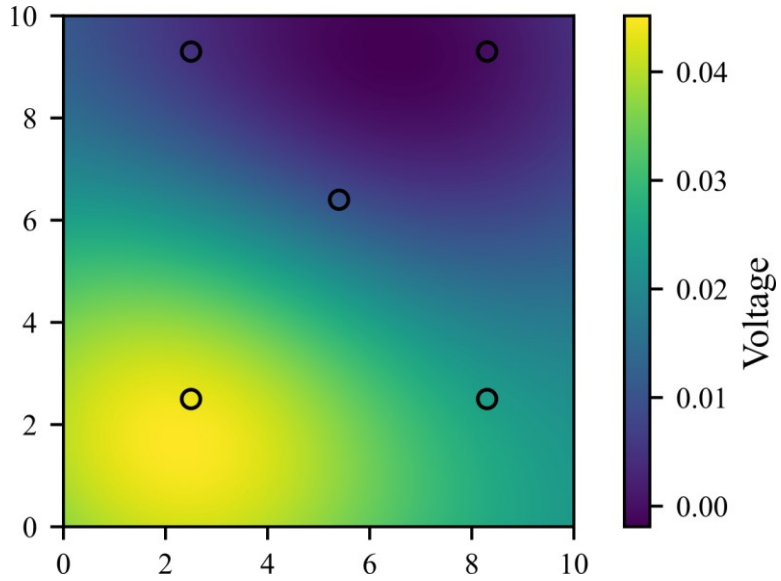
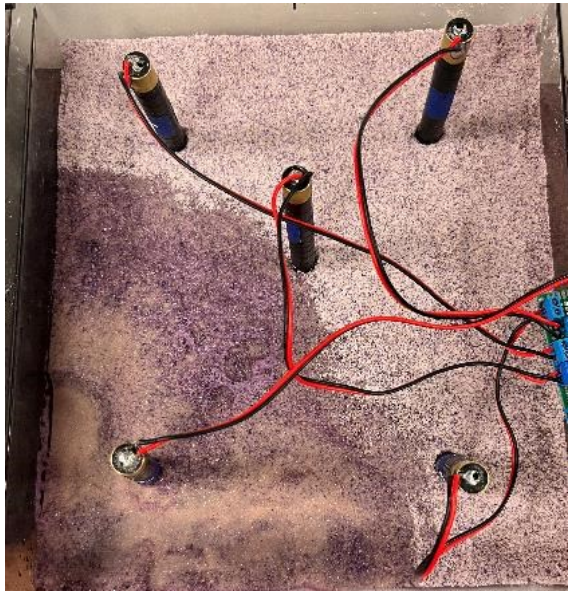
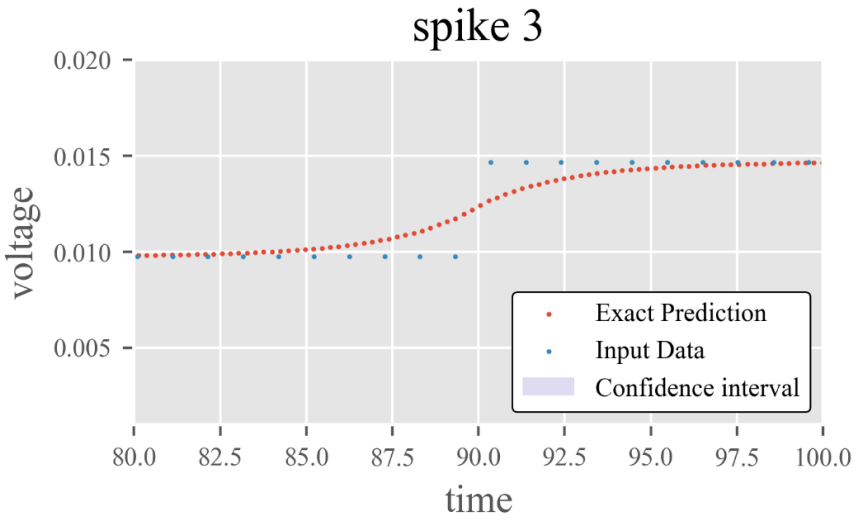
MORE EXPERIMENTAL WORK (MOISTURE TEST)

- UAV-deployable smart sensing nodes for soil conductivity levels in levees
- Spatial kriging for single timestamp.
- Temporal Kriging.







CONCLUSION

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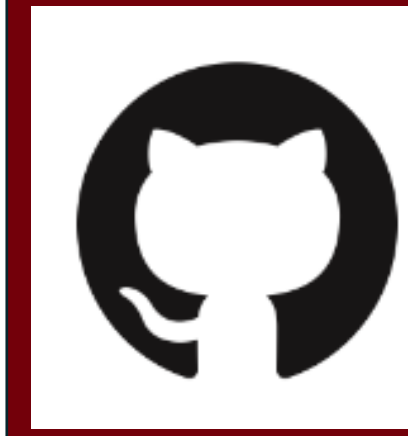
CONCLUSION

- The introduction of a stand-alone sensor package for structural health monitoring of earthen levees.
- Demonstrated the sensing platform in lab-scale testing.
- The package can detect the slight variations in ground velocity and moisture levels before structural failure.



Open-Source hardware Designs

https://github.com/ARTS-Laboratory/Smart-Penetrometers-with-Edge-Computing-and-Intelligent-Embedded-Systems

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ACKNOWLEDGEMENT

The National Science Foundation provided support for this work through Grants 2152896 The National Science Foundation's support is sincerely thanked. The authors' opinions, results, conclusions, and recommendations in this material are their own and do not necessarily reflect the views of the National Science Foundation.

THANKS!

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