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Autonomous Indoor Localization via Field Mapping Techniques, with Agricultural Big Data Application

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- This joint collaboration between the library, the Mechanical Engineering department shows the current research of localizing an Android smartphone using big data collection and sensor fusion techniques. Our original work is Autonomous Indoor Localization via Field Mapping Techniques which primarily designed as indoor fire and safety aid.
- For Agricultural Big Data Use, the Android smartphone is being applied to in indoor greenhouse fire, safety and data knowledge design. Such may aid big data tool value to greenhouse fire and safety design and any data that may be important fieldwork considerations.
- Our indoor agricultural mapping application may be application to greenhouses in indoor growing labs that promote educational and resource management capacity.
- For **Big Data management** we intend to utilize the **CRIS (Figure 1)** scientific workflow system and Purdue ionomic information management systems design by Benjamin Branch, Peter Baker, Jia Xu, Elisa Bertino.

Big Data

The problem: Large sets of field data work, design and collection may be based or correlated to greenhouse research output where such correlation may be lost from greenhouse to field work set-up.

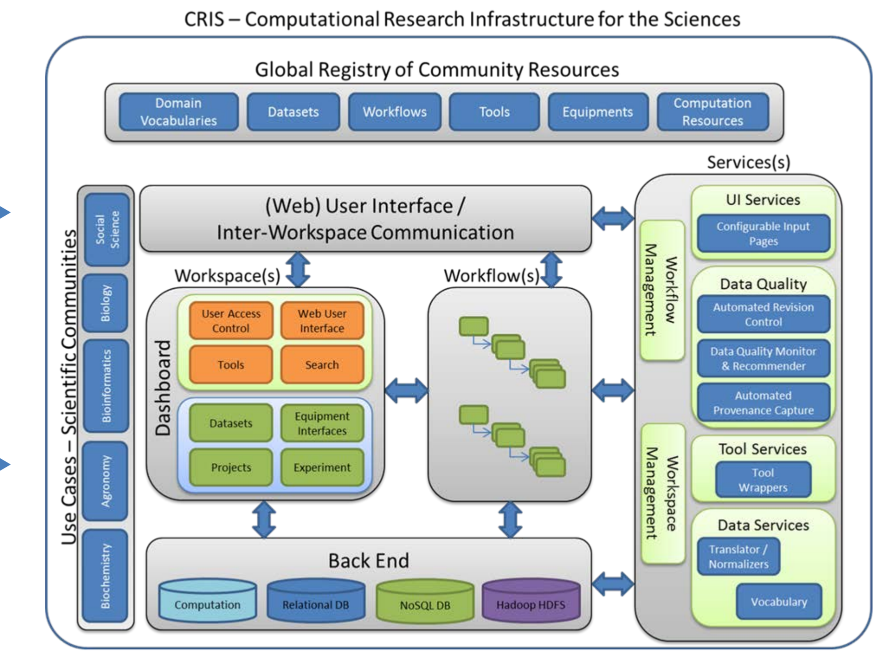
A practical solution: An indoor greenhouse map may aid its design, research capacity and linkages to applicable field work that further supports greenhouse research. Smartphone indoor mapping of greenhouses may allow field work to be linked, verified from greenhouse findings or assumptions and better influence future or aid future fieldwork considerations.

Data that may be influence from greenhouse databases and design set-up
- Agricultural Security (water, drought and unknown risks)
- Pest and Pesticide monitoring
- Building geospatial framework for governmental data sharing (metadata)
- Soil type identification
- Water security
- Food production forecasting
- Crop disease study
- Food contaminant study
- Drone use for crop monitoring (what to monitor)
- Weather & Climate data
- Weather and Climate forecast
- Invasive Species Analysis

Greenhouse Smartphone Applications

Here, smartphones could utilize a specific datasets for researchers use for a particular aspect of crop issues. In the future, data collection from field sensors in an automated manner using the smartphone and a Wi-Fi as data ingesting tools to the backend of big data repository may become a big data norm.

Greenhouse

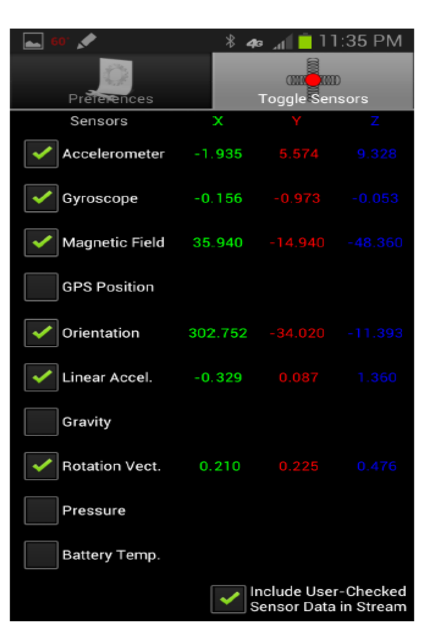


Backed Data processing and curation with Computational Research Infrastructure for Life Sciences (CRIS) ***Figure 1***

Indoor Smartphone Applications

We have shown cell phone geolocation to within 20cm indoors using a magnetic field map, and the magnetometer and inertial sensors available on all smart phones. Our results are from a corridor in the Purdue ME building. Our method is novel and uses the disturbances in the indoor magnetic field vectors—caused by iron in construction, furniture and appliances—as beacons for pin pointing position. Our method is applicable to areas where the magnetic map does not change faster than it can be mapped, i.e., any indoor space where spatial concentrations of ferrous materials remain static such as libraries, offices, or hotels. Our algorithms have clear mathematical properties in that geolocation errors depend only on the resolution of the sensors and the size of magnetic disturbances in the environment.

Android smart phone

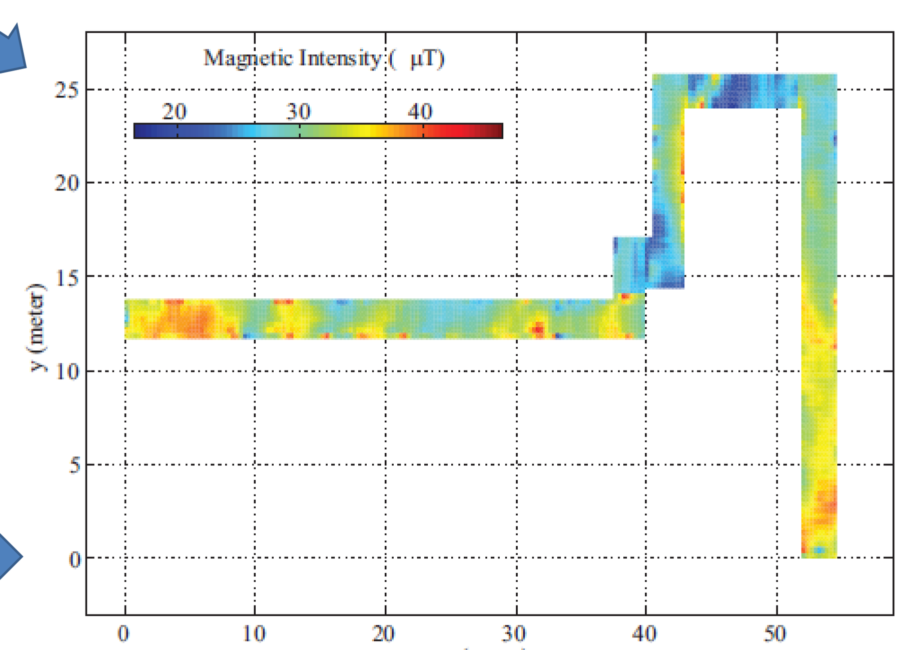


sensor data collection

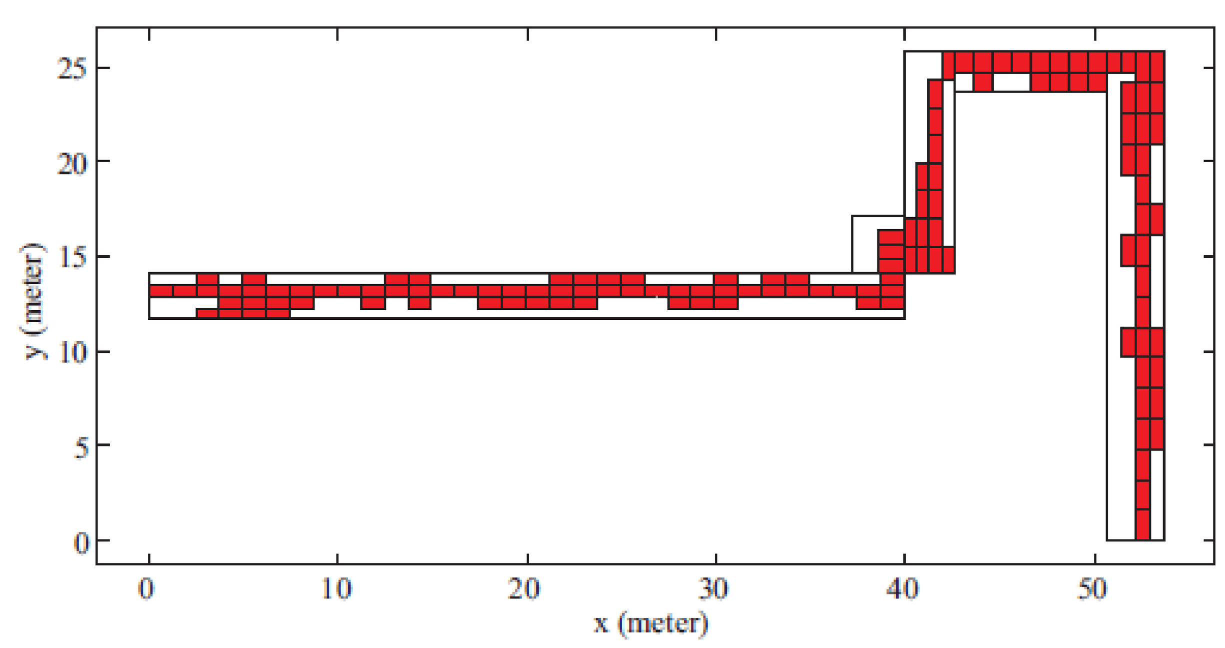
GIS application:

In prior work, funded by Google Inc., we had to manually construct the map by taking a magnetometer to every square foot of the space, something inconvenient for large scale application. We have developed algorithms to automate this map construction, using only data from cell-phone users—various sensor measurements from cell phones including inertial data, magnetic fields, and wireless signal strength from both cell towers and Wi-Fi access points. They need a lot of testing both in single user and multi-user scenarios to understand the efficiency of map building in practice. Our algorithms use a combination of virtual pedometry [1], ranges to wireless transmitters, and magnetic field measurements (as in references [2] and [3]).

Current geolocation algorithms:
- received signal strength (RSS), error 3~5m
- time difference of arrival (TDOA), error 2~3m
- radio frequency identification (RFID), error 3~5m
- <u>our algorithm (Magnetic map), error: 1.5~2m</u>



magnetic field intensity map



localization result

Data from smart phone:
- acceleration (3-axis)
- angular rate (3-axis)
- magnetic field intensity (3-axis)
- RSS signal strength

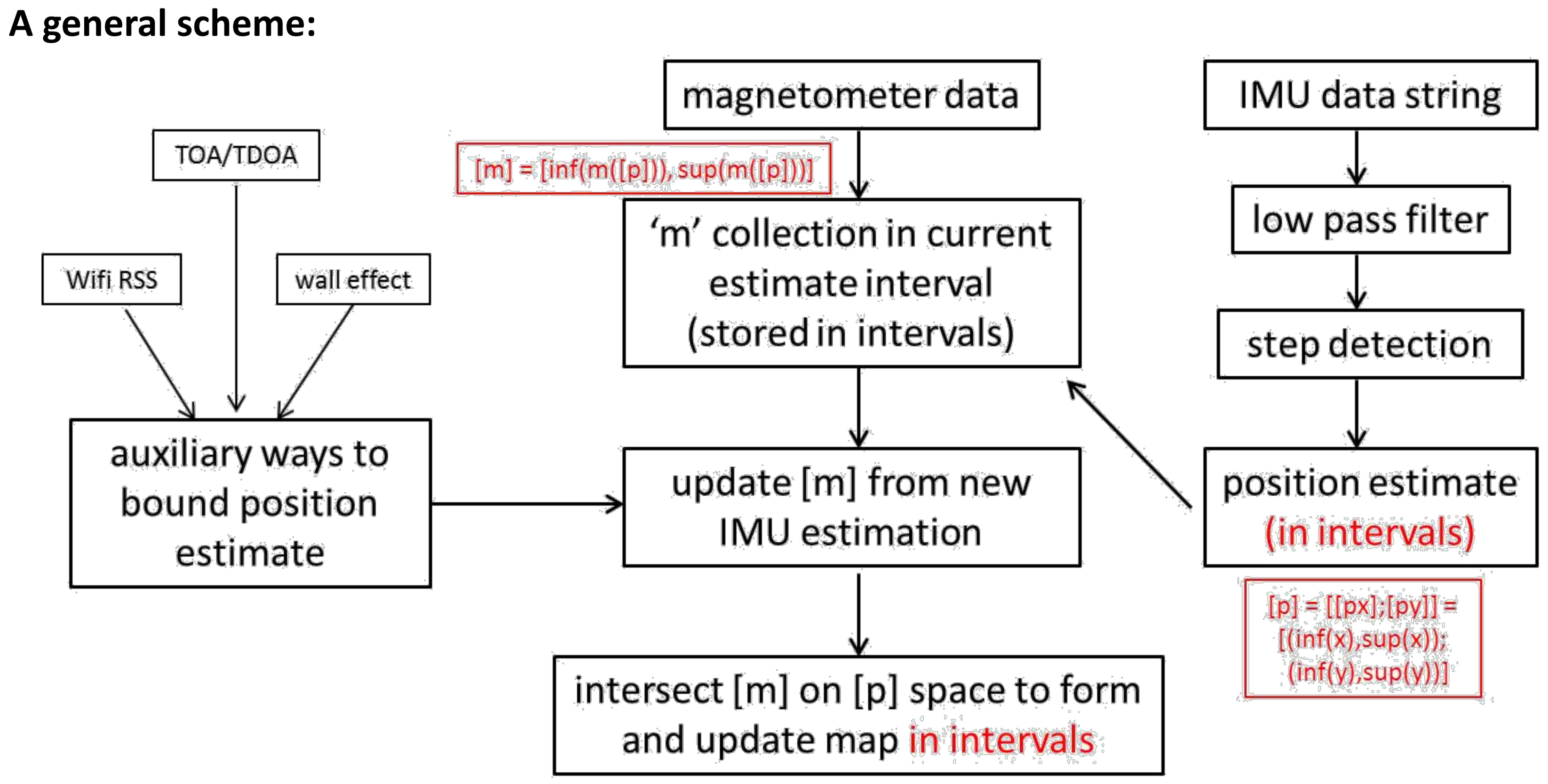
Functions after data processing:
- indoor/outdoor localization
- autonomous field map construction
- real-time map update from server
- step detection and orientation

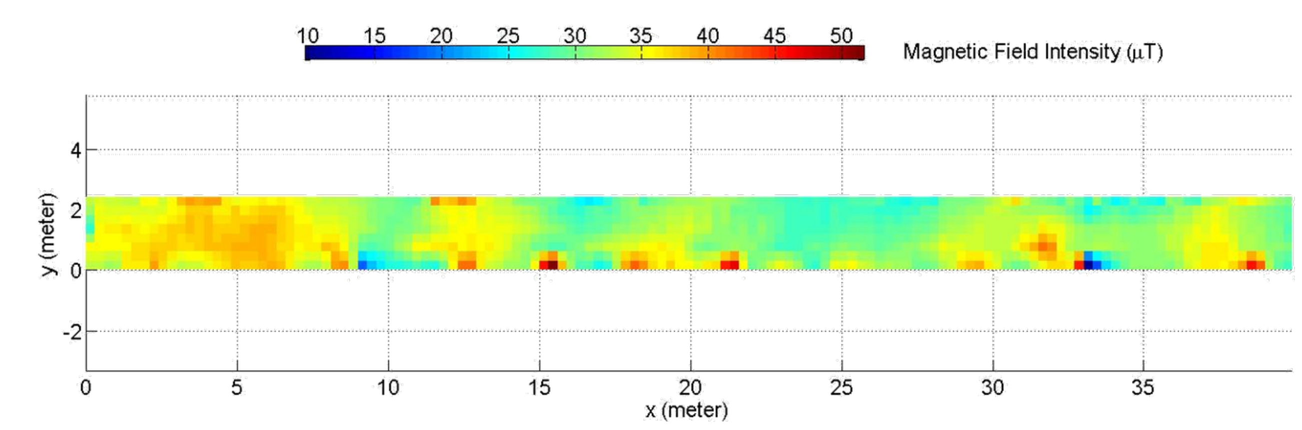
Future Considerations: Include Google's Tango Project where we are working to bring into our toolset for application and discovery

Autonomous Map Construction:

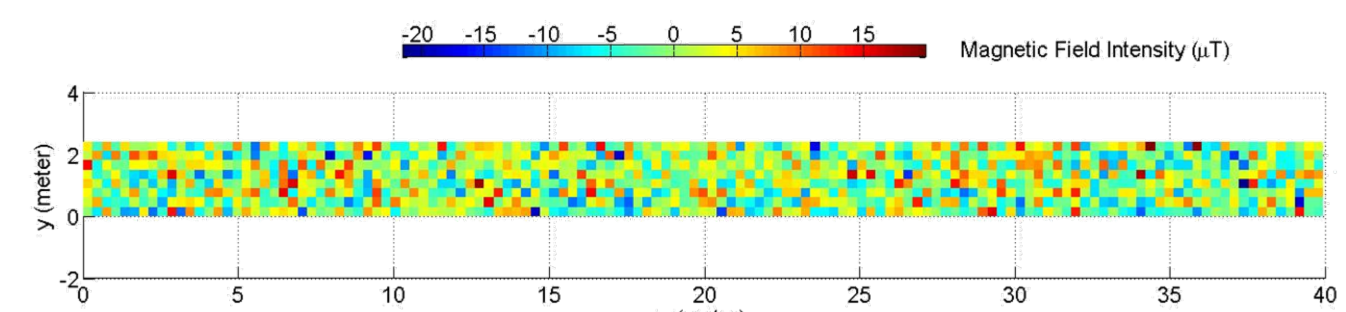
We therefore test various algorithms in realistic scenarios in other area, with voluntary users contributing cell phone data to test the algorithms. The data from individual cell users will consist of sensor data mentioned above along with specific calibration characteristics of individual sensors on their phones so data from various devices can be suitably collected in mass. Our work thus involves the dynamic collection and processing of ***big data*** to produce ***compact map information*** (in terms of processing and memory needs) available for use to all users through a cell phone application. Purdue is currently processing a patent application that covers the IP in a variety of areas—there are several licensing opportunities in both safety and resource location, besides security.

A general scheme:





mean value distribution of [m] on a map



std value distribution of [m] on a map

<u>References:</u>

[1] <u>Cui,Y.</u> and Ariyur,K.B. (2011). "Pedestrian Navigation with INS Measurement and Gait Models," Proceedings of the 24th International Technical Meeting of the Satellite Division of the Institute of Navigation (ION GNSS) , Portland, OR, Sept. 2011, pp. 1409-1418.

[2] <u>Cui,Y.</u> and Ariyur,K.B. (2012). "Augmenting Cell Phone Geolocation via Magnetic Mapping," Proceedings of the 25th International Technical Meeting of the Satellite Division of the Institute of Navigation (ION GNSS) , Nashville, TN, Sept. 2012, pp. 2469-2473.

[3] <u>Cui,Y.</u>, An,R., and Ariyur,K.B. (2013). "Cell Phone Geolocation via Magnetic Mapping," submitted to Automatica, under review.

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