

Designing Technology for the Developing World

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About Me

- Grad Student at UW in Programming Languages, Compilers, Parallel Computing
- Taught Computer Science at the University of Virginia for 5 years
- Grad Student at UW: PhD in Educational Technology, Pen Computing
- Current Research: Computer Science Education, Computing and the Developing World
- Courses Taught: data structures, compilers, architecture, programming languages, data programming in Python, Unix Tools, Designing Technology for Resource-Constrained Environments

Outline

- Technology and the Developing World
- Improving Transportation
  - in Bishkek, Kyrgyzstan
- Improving Maternal Health
  - in Uganda
- Other projects at UW

Information & Communication Technology for Development (ICTD)

- An active area of research in computing
  - Research groups at: UW, UC Berkeley, GaTech, Michigan, Cornell
  - Microsoft, IBM
  - 9th ICTD conference: http://ictd2017.itu.edu.pk/
  - 7th ACM DEV conference: http://acmdev.org
- **Interdisciplinary field**: public health, education, agriculture, business
- **Goal**: Improve lives of people in developing regions through use of technology

Technology in the Developing World

- **Health**
  - Monitoring vaccines & vaccinations
- **Education**
  - Increasing access to high quality teachers in rural areas
- **Agriculture**
  - Teaching new & effective farming practices
- **Business**
  - Improving microfinance record keeping with cell phones in India

Photos: Open Data Kit

Designing Technology for Unfamiliar Environments

- Physical Environment
  - Low cost (e.g. cell phone)
  - Low power (e.g. car battery, human power)
  - Low connectivity (to Internet)
- Users & Cultural Context
  - Illiterate users
  - Familiarity & trust of technology

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Transportation is Important

- Provides access to:
  - markets
  - work opportunities
  - health care
  - education
- Public transportation

Bishkek, Kyrgyzstan

Transportation is a common challenge: unpredictable, unsafe, and inefficient.

Marshrutka in Bishkek

Marshrutkas in Bishkek

- Marshrutkas – private mini buses
  - Set routes
  - No set bus stops
  - No expected arrival times
- Users have no idea when bus will arrive
  - Predictability
  - Personal safety waiting for bus

Goal: help users determine when next bus will arrive.
Allows safer, more efficient system, encouraging ridership.

Design Questions

- What technology to use?
  - Use technology that is available to users
  - Keep costs low
- How to predict when bus will arrive?
  - Set routes
  - No set bus stops
  - No expected arrival times

Where is the bus right now?

Problems to Solve

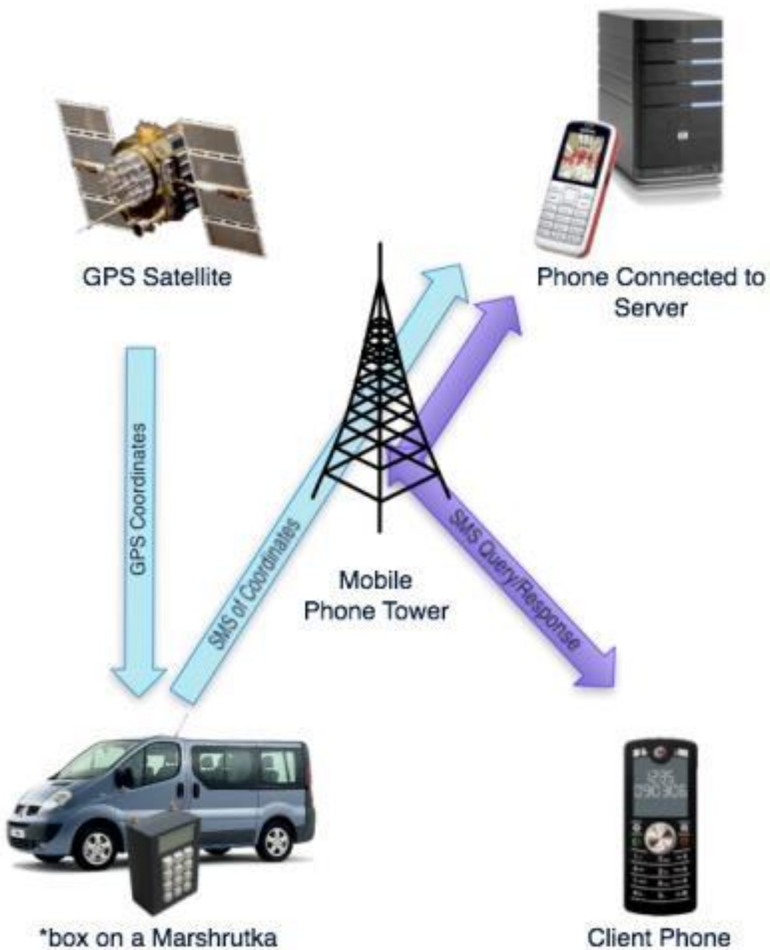
- How to **determine** where bus is?
- How to **tell the user** where the bus is?

Bus

User with
cell phone

A *box

*bus System



GPS Satellite
Phone Connected to Server
GPS Coordinates
SMS of Coordinates
SMS Query/Response
Mobile Phone Tower
*box on a Marshrutka
Client Phone

Geo-Coding Locations

Rider is at a location they would like to tag.

A bus with unique *bus-id* “123” goes by. (e.g. license plate #)

Rider sends the server a message: “store 123 as home”

Server stores rider’s private location name.

Rider can use the location “home” in future queries.

Evaluation in Bishkek

- March 2009
- Interviews of Bus Riders and Drivers
- Measurements of Infrastructure
- *boxes on several bus routes
- Testing prediction & geo-coding accuracy
- Usability Testing in lab setting

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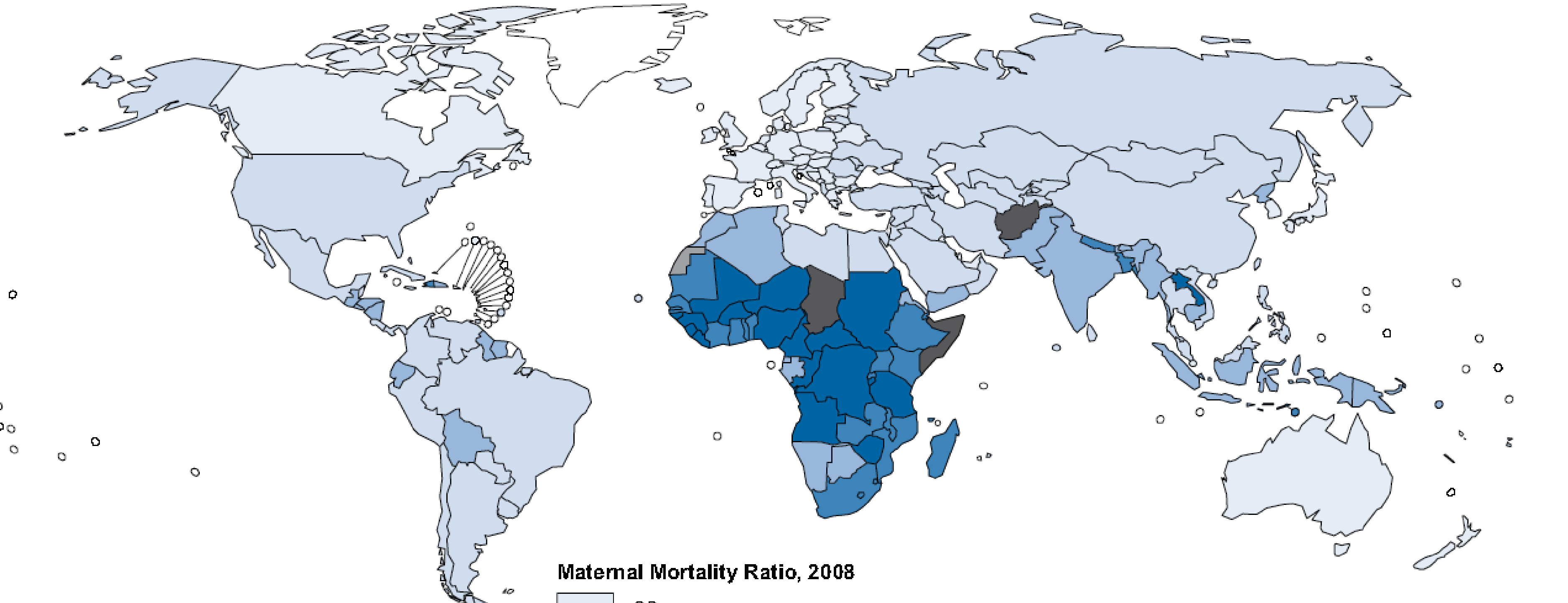
Maternal Mortality



Maternal Mortality Ratio = Deaths per 100,000 live births

- **Estimates lifetime risk of maternal death**
  - **1 in 4300 for developed regions**
  - **1 in 120 for developing regions**
  - **1 in 31 for developing regions in sub-Saharan Africa**

Maternal Health in Uganda

- 89% of births occur in rural areas
- 58% of deliveries occur at home

- If problems occur, travel time to health facility can be long
- Few doctors

Training Midwives

- Dr. Rob Nathan, UW Radiology
- **Idea**: Train midwives to use ultrasound to screen for common complications
  - **Midwives** - central trusted medical figures
  - **Ultrasound -** used widely in developed world
- allows women to plan for travel to medical facilities

Commercial Ultrasound Systems

Challenges

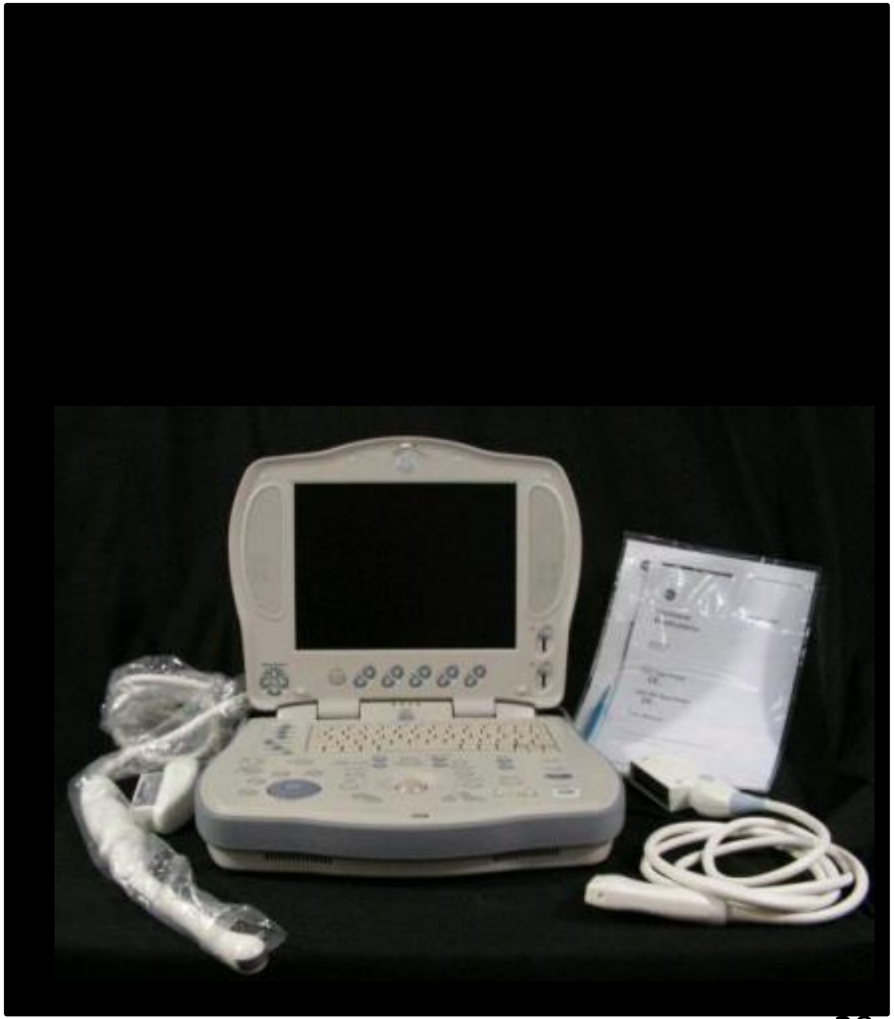
- **User interfaces** for commercial ultrasound machines are **complex**
- **Training** midwives is difficult
- Commercial ultrasound machine are **expensive**

Commercial Portable Ultrasound

Device includes UI elements and additional features to diagnose conditions in multiple domains: **Abdominal, OB, Vascular, Cardiac ,Thyroid, Breast, Etc**

Monolithic Architecture

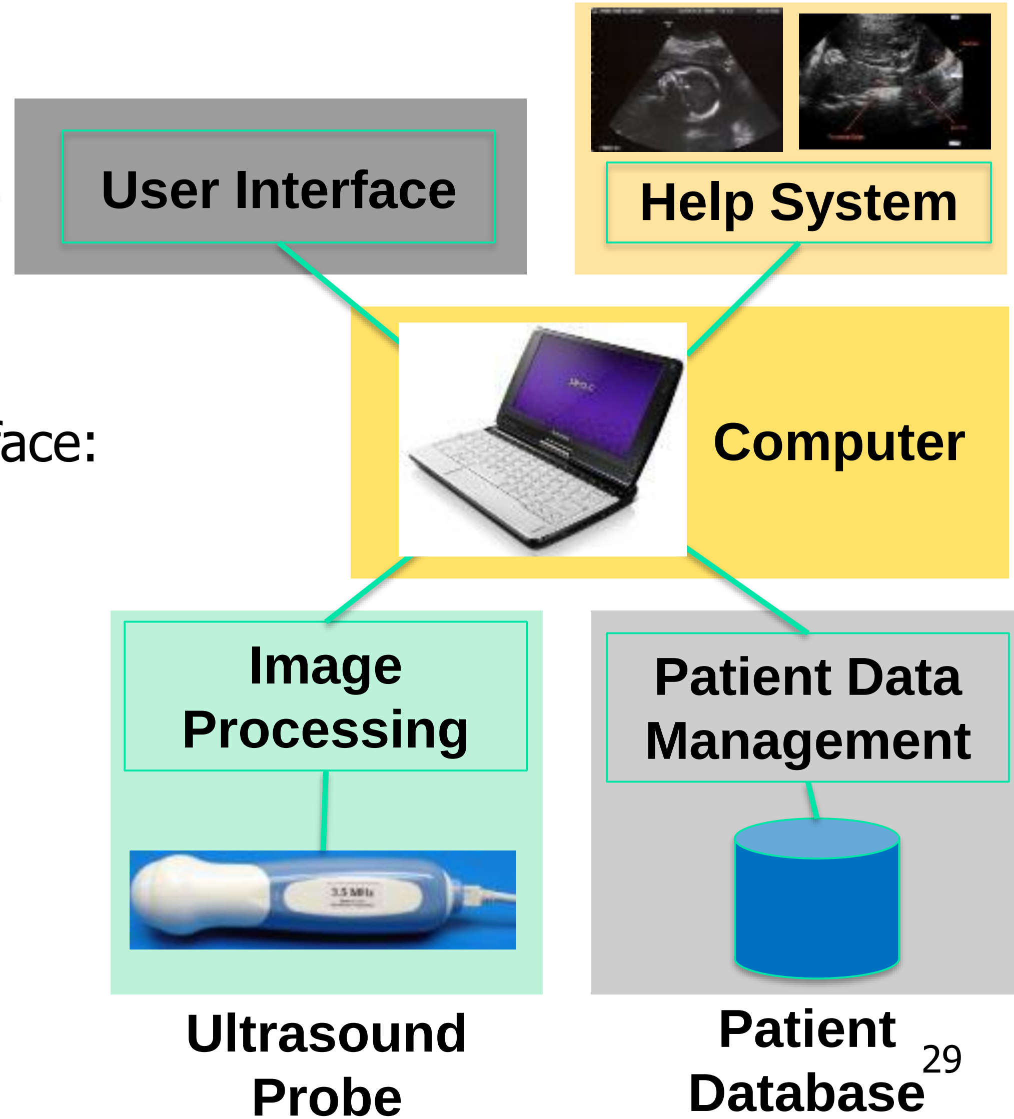
Midwife



- General user interface designed for multiple use cases
- System is tightly integrated
  - Probe
  - Hardware
  - Software

Modular Architecture

Midwife



Allows customization of User Interface:

- Hide Un-needed Functionality
- Language support
- Interactive Help System

Decouples System Choices:

Durability

Recharge/Power requirements

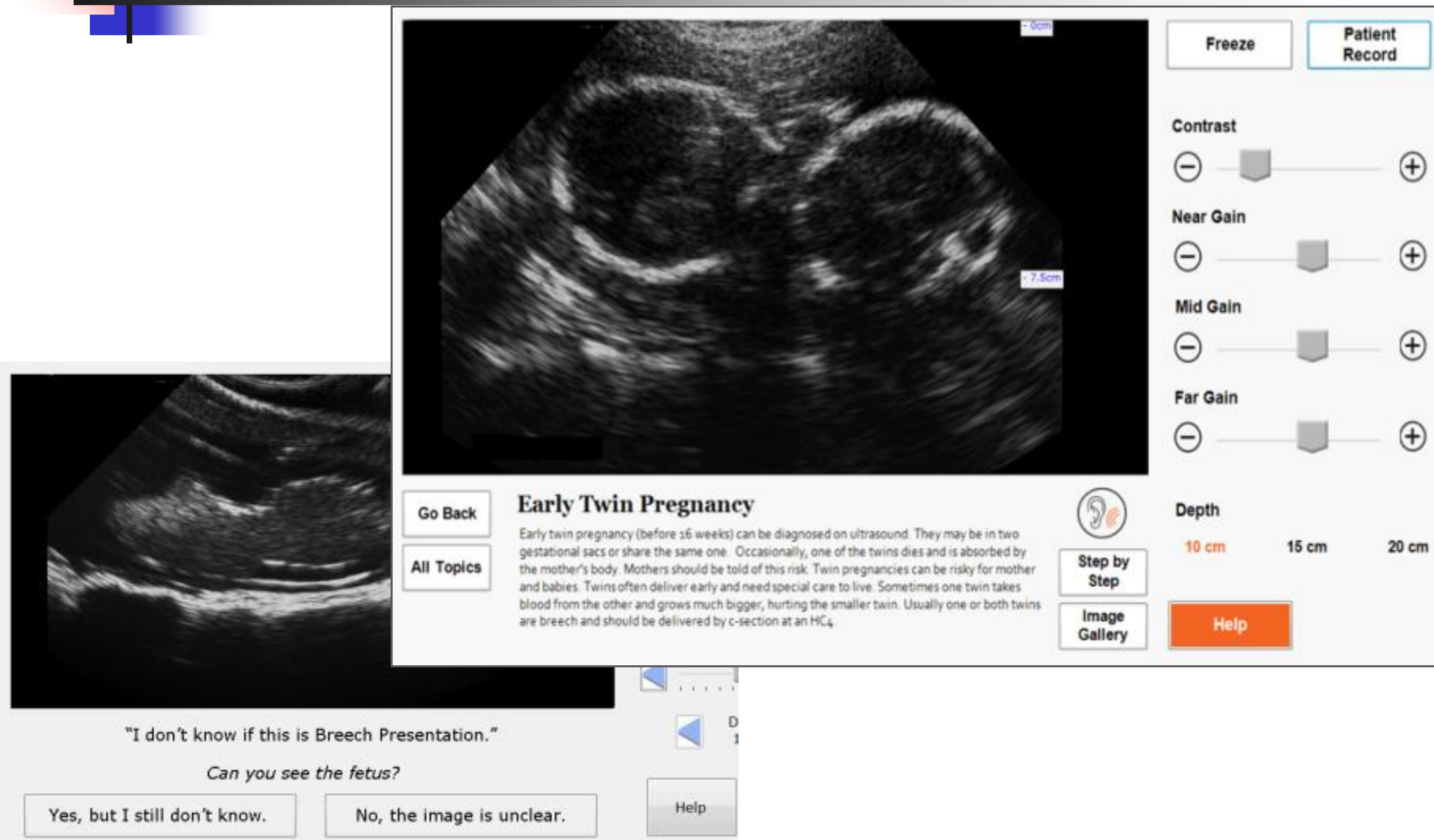
Portability

Patient Record Systems

Ultrasound PLUS

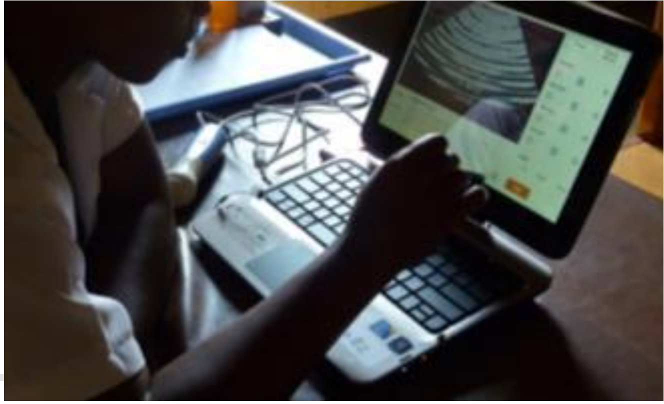
Simplified User Interface

Help System



Freeze
Patient Record
Contrast
Near Gain
Mid Gain
Far Gain
Go Back
All Topics
Early Twin Pregnancy
Early twin pregnancy (before 16 weeks) can be diagnosed on ultrasound. They may be in two gestational sacs or share the same one. Occasionally, one of the twins dies and is absorbed by the mother's body. Mothers should be told of this risk. Twin pregnancies can be risky for mother and babies. Twins often deliver early and need special care to live. Sometimes one twin takes blood from the other and grows much bigger, hurting the smaller twin. Usually one or both twins are breech and should be delivered by c-section at an HC4.
Step by Step
Image Gallery
Depth
10 cm
15 cm
20 cm
Help
"I don't know if this is Breech Presentation."
Can you see the fetus?
Yes, but I still don't know.
No, the image is unclear.
Help

Fieldwork & Initial Evaluation



- Design Iteration in Seattle (2010)
  - Survey sent to Ugandan midwives
  - Interviews with Ultrasound instructors
  - Prototype evaluation with local midwives
- Fieldwork in Uganda (March, June-July 2011)
  - Observe work practices of midwives
  - Focus groups with Ugandan Mothers
  - Feedback on prototype system

Appropriate & Sustainable Ultrasound System

- Leverages existing systems, processes, and resources
- Customizable user Interface
- Help System
- Off the shelf parts
- Minimize Cost
  - Equipment Cost
  - Training Cost

Social Implications

- Mothers who see Ultrasonic Images become more engaged in their pregnancy
  - May be more likely to return for follow up visits, vitamins
  - May help engage husbands, mother-in-law
- Sex determination
  - Male children preferred in some societies

- Introducing technology can change dynamics
  - Decreased communication with midwives
  - Deliver bad news

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  - Open Data Kit
  - Digital Financial Services

More Course Projects

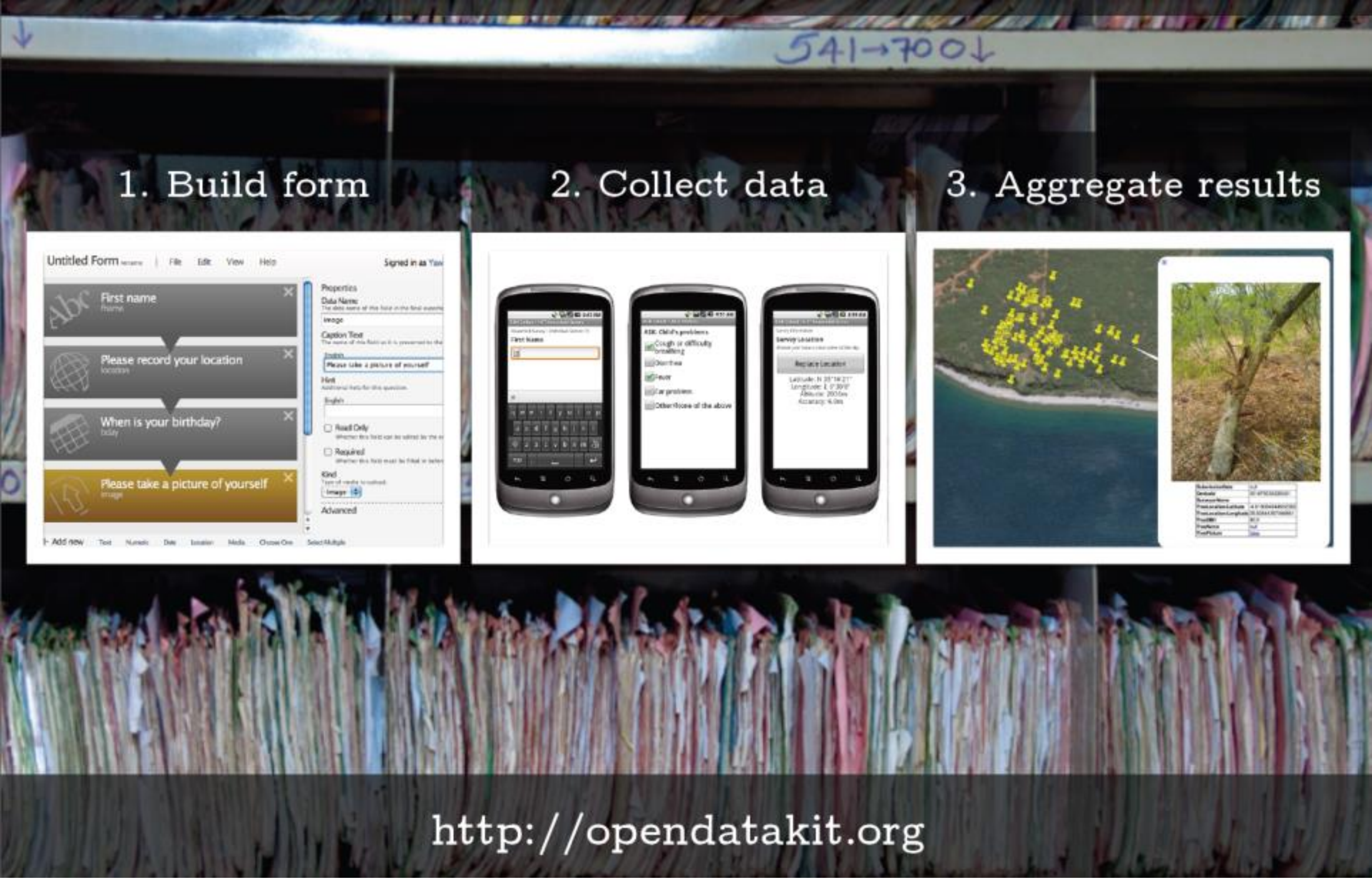
- **Multilearn** – allow local schools to use limited computers more effectively
- **Milk Bank** – milk pasteurization sensor and record keeping for breast milk bank in South Africa
- **Water Use** – sensor to record movement of water collection vessels in Ethiopia
- **Global 2 Local** – translator service for local immigrant communities
- **Vaccine Registry** - mobile phone application to track children and immunizations
- **Pregnancy Reminders** – send automatic reminders to mothers in Kenya via SMS

Open Data Kit (ODK)

- **First release in 2009 (started in 2008)**
- **Mobile data collection tools for Android devices**
- **Modular, open architecture**
- **Open source (Apache2 license)**

http://opendatakit.org

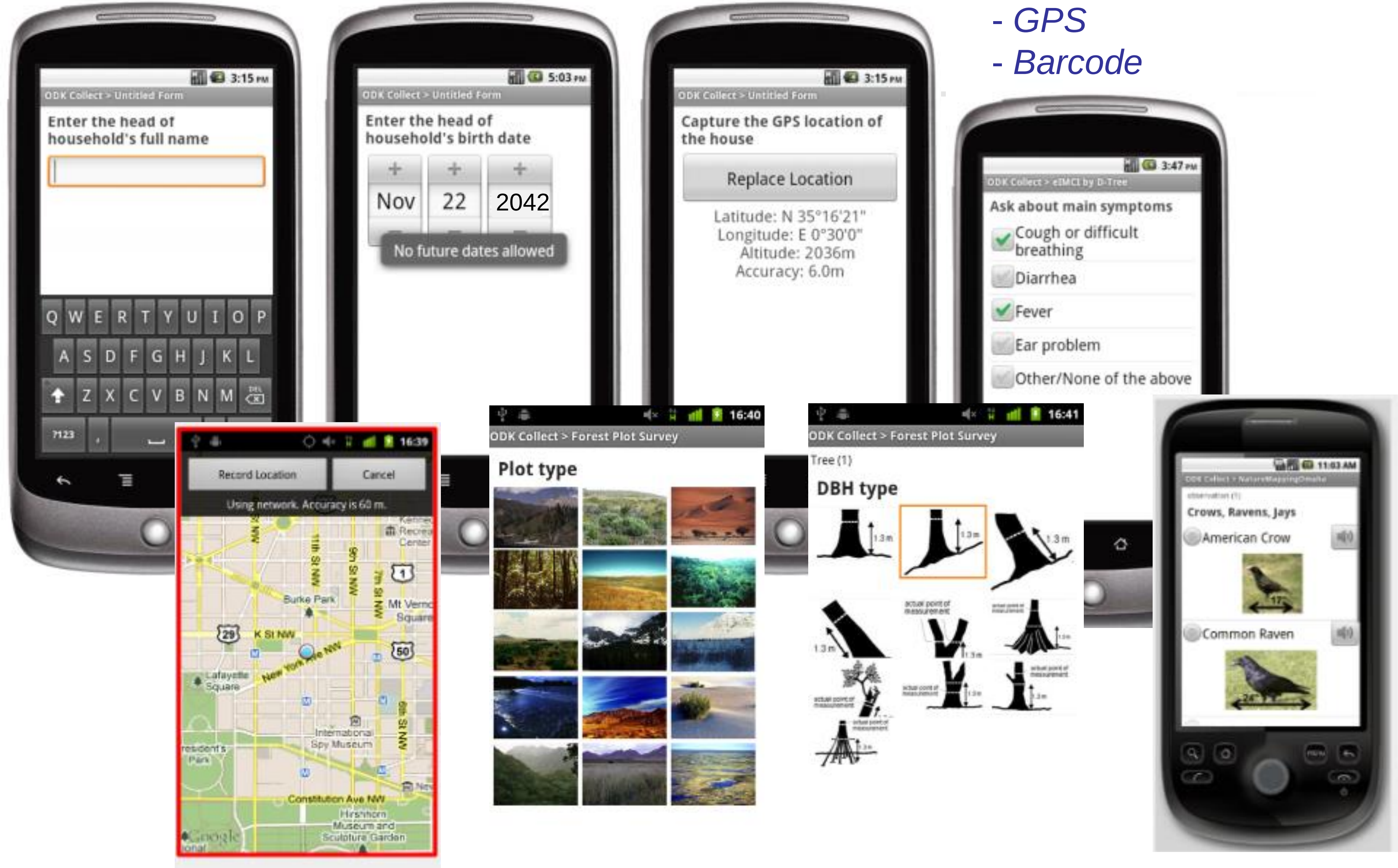
GOAL: ***Magnify human resources through technology***



GOAL: ***Magnify human resources through technology***

ODK Collect

Automated Survey Renderer
with enhanced data types
- Pictures, Video
- GPS
- Barcode



ODK Deployments

- Tanzania - Jane Goodall Institute and Google.org are piloting ODK for forest health monitoring.
- Kenya - USAID-AMPATH uses hundreds of phones with ODK for home-based HIV counseling and testing of millions of rural Kenyans
- Liberia - Harvard Humanitarian Institute documents human rights violations using Kobo -- a tool built from ODK.

- MANY More deployments here: https://opendatakit.org/about/deployments/

Digital Financial Services (DFS)

- How can the lives of the billions of people who live on a few dollars a day be improved?
- Multiple factors
  - Health, governance, education, poverty, food security, environment, infrastructure, civil strife
- DFS can be a pathway out of poverty

Improved financial services help

- Strong evidence that improving access to financial services can help people stay out of poverty
  - Poor pay more for services
  - Create new livelihood opportunities
  - Allow more efficient delivery of other services
  - Savings provide a buffer against financial shocks

Financial services for the poor

Improved access to financial services is recognized as an important mechanism for raising people out of poverty

- Financial Services for the Poor
  - Remittances
  - Savings accounts
  - Government payments
  - Digital payments
  - Insurance

Basic Financial Services

Mobile Money

- https://www.nytimes.com/2017/05/09/opinion/in-kenya-phones-replace-bank-tellers.html
- Send money to remote location
- No bank accounts, but mobile phones
- Rely on basic mobile phones

DFS Research challenges

- Security of mobile money
  - Android app security
  - Usability and resilience to poor infrastructure are key
- Usability
  - Simplification of process
  - Lack of trust is a deterrence to adoption
- Fraud detection
  - Transaction records to detect potentially fraudulent use
- Consumer Education
  - Understanding of basic financial instruments
- Integration of mobile money into broader services
  - Payment for services (e.g., school fees)

Accessible Technology at UW

- Accessibility Technology Research
  - http://www.cs.washington.edu/people/faculty/ladner/research
- Taskar Center for Accessible Technology
  - http://tcat.cs.washington.edu/

Questions?

Email me!

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ICTD Research at UW:

http://ictd.cs.washington.edu/

change http://change.washington.edu

Meets every Tues at noon-1pm in cse 203, All are welcome!