Personal ultrasound teaching simulator

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OBJECTIVE

To develop a widely accessible simulator for teaching ultrasound scanning to medical students, trainees, and interested clinicians.

BACKGROUND

Simulators are a valuable tool for teaching and training ultrasound scanning.

High-fidelity simulators enable an active and low-risk, safe learning environment, and allow for reproducible standardized assessment.

Limitations of commercially available simulators are:

- Cost considerations ($ 3,000 to > $ 50,000)
- Purchased primarily by teaching institutions, with lack of student and trainee access outside of dedicated laboratory time
- Too expensive even for teaching institutions in Low and Medium Income countries (LMICs)

Specific to LMICs, the increasing use of ultrasound has led to an acute shortage of trained personnel. The vast majority of providers in LMICs have received less training than World Health Organization standards.

METHODS

We developed a free ultrasound simulator, which is implemented as a downloadable software program: Persimus (PERsonal SIMulator for UltraSound, www.persimus.org).

The software program was written in the Javascript language.

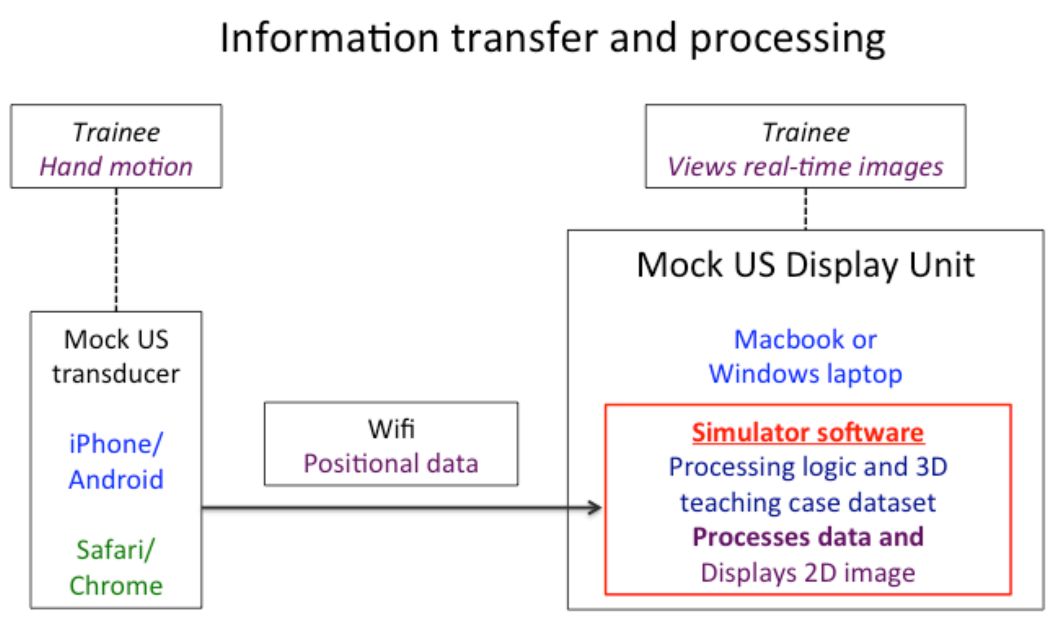
The use of open web-based standards (HTML/CSS/JS) allows the program to work in any combination of:

- Macbook **or** Windows 7/10 laptop as the *"mock ultrasound machine"*
- iPhone **or** Android smartphone as the *"mock ultrasound transducer"*

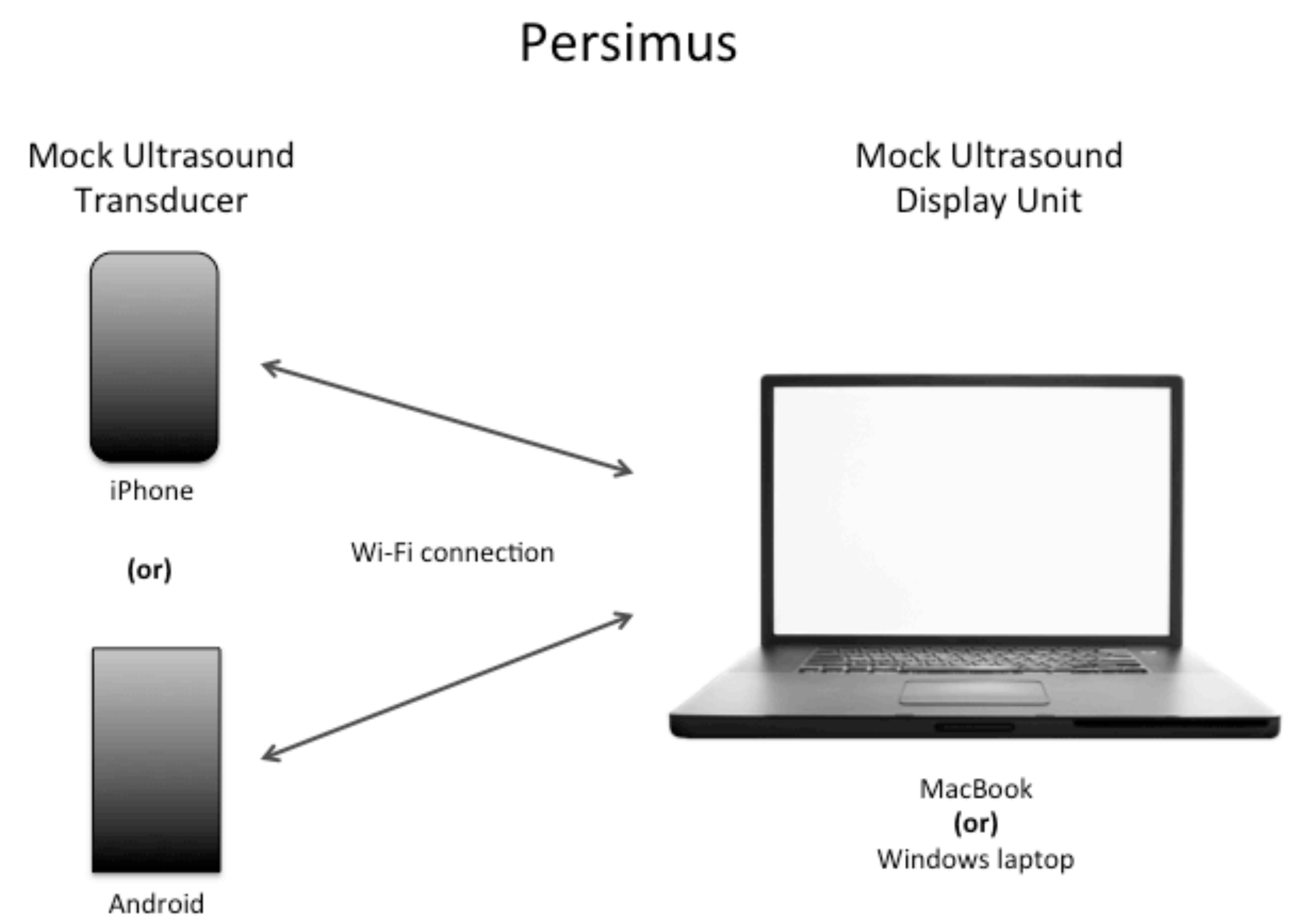
The simulator program itself is installed on the laptop computer and contains:

- Programming logic for connecting the smartphone and laptop computer using a WiFi connection
- Programming logic for retrieving and processing positional information from the smartphone (*mock ultrasound transducer)*
- 3-dimensional imaging datasets of teaching cases
- Textual material explaining the salient clinical and imaging findings

Teaching case material was developed from ultrasound images and cine clips in the PACS system of the Radiology Department at Yale-New Haven Hospital.



Schematic representation of information transfer and processing by Persimus. Positional information from the trainee's hand movements are captured in real time by the smartphone's accelerometer and gyroscope and transmitted via a Wifi connection to the laptop computer running the Persimus program. The data is then processed by Persimus, and 2D ultrasound images from its teaching case database are dynamically displayed, enabling the development of the learner's visual-motor skills.



Overview of the Personal ultrasound simulator (Persimus) system. An iPhone or Android smartphone functions as a "mock transducer" and images are displayed on a Macbook or Windows laptop PC, which serves as a "mock ultrasound unit".

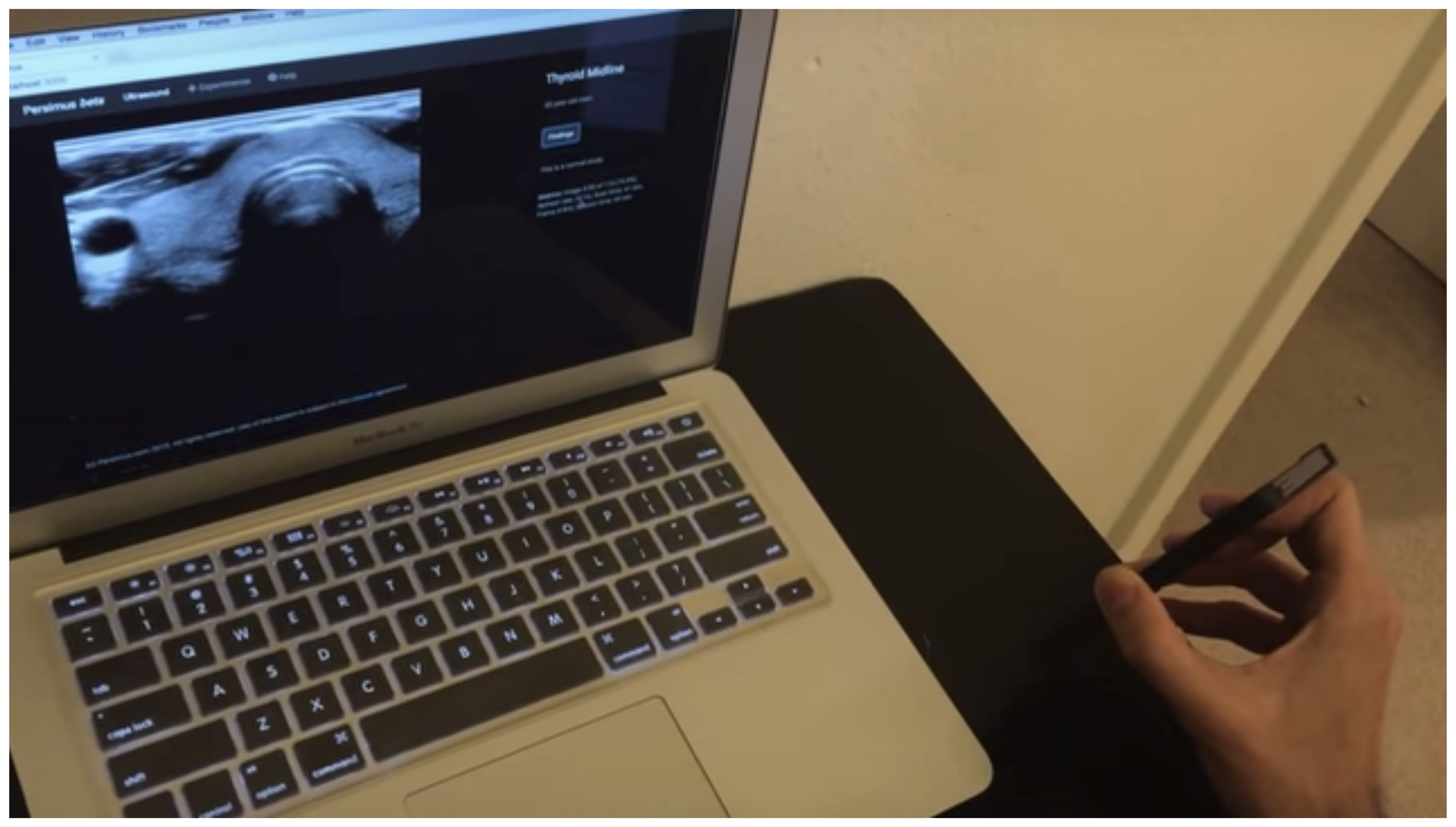
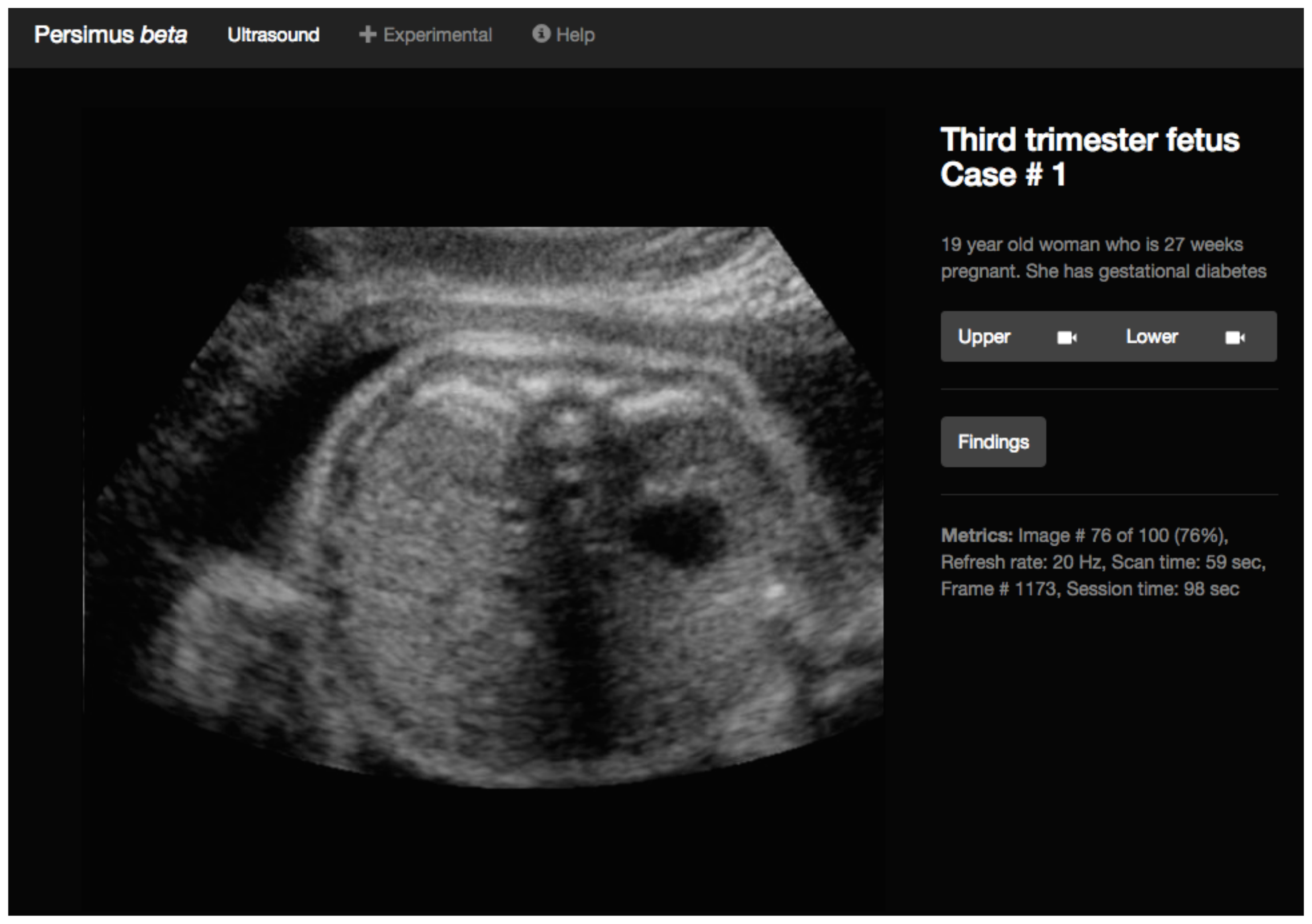


Image showing the Persimus program being used. The iPhone (right side of image) is the "mock transducer" and images are being displayed on a MacBook Air (left side of image), which is the "mock ultrasound display unit".

A video demonstration may be viewed at: www.persimus.org/demo



Screenshot image of the simulator software user interface. To the right of the screen, the patient's history is provided with buttons for navigating the views of the body. The simulated image is displayed in real-time on the left side of the screen.

RESULTS

One teaching module (ultrasound of superficial tissues) with 20 teaching cases, including both imaging datasets and explanations was developed.

This was then disseminated to:

- Yale first year medical students
- Yale Diagnostic Radiology residents
- Yale Emergency Medicine residents
- Radiology residents in Muhumbili National Hospital, Dar-es-salam, Tanzania as part of Yale Radiology's Global Outreach Program
- Physicians and trainees in several other countries (Cameroon, Ghana, India, Kenya, Netherlands, Nigeria, Rwanda, Uganda, Zambia, Zimbabwe) that requested an early preview of the simulator

Feedback received from users:

- *"The interaction is great for being able to understand how a structure looks while physically scanning and to be able to go back and forth and stop when needed."*
- *"The teaching interface was very intuitive and user friendly."*
- *"Fun to use"*
- *"Excellent idea"*
- *(Liked the) "ability to interact with reference images to understand 3D orientation"*

Since the simulator uses widely available existing hardware (smartphones and laptop computers), it can be deployed and disseminated as a free or very low cost software program downloaded from the Internet, rather than as an expensive hardware purchase.

CONCLUSIONS

Personal ultrasound simulators are technically feasible, and have the ability to greatly improve access to ultrasound simulation in medical education, both in high human development index countries, as well as in resource-limited settings.

The simulator can also be readily used for teaching ultrasound scanning using a blended learning approach.

FUTURE DIRECTIONS

Currently developing two more teaching modules:

- Ultrasound of neck
- Ultrasound of scrotum

We will be disseminating these modules within and outside of Yale in the next three months.

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