Webcam for Medical Point-of-Care Microscopy

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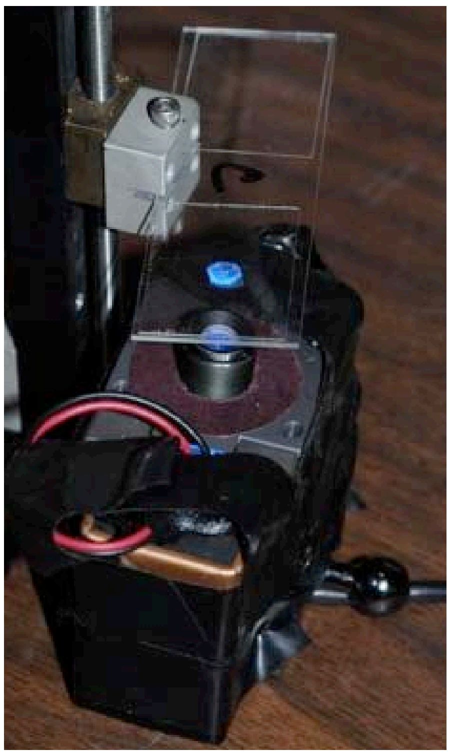
Problem Statement: Medical diagnostic tools are woefully lacking in the developing world, especially in rural areas. Such tools are often complex, fragile, expensive, and require skilled operators, technicians, and spare parts. Thus if they exist and function at all, they are centralized in major cities far from rural needs. Medical specimens such blood, urine, feces, and tissue samples, must be carefully transported long distances for assaying, risking degradation and contamination. Assay results must then be conveyed back to the rural physician and patient, adding confusion and challenges where communication infrastructure is lacking.

Proposed idea: This mentor and his startup company, EtaLuma Inc. have developed a radically inexpensive (~$100) and powerful medical diagnostic tool by converting a $10 web camera (webcam) and any computer into a fluorescent microscope with performance comparable laboratory diagnostic microscopes costing tens to hundreds of thousands of dollars. Thus any doctor with an inexpensive laptop computer can do fluorescent microscopy at the point of care. If the results require further analysis, they can be sent electronically to medical specialists, rather than transporting biological samples.

Existing Solutions: Medical testing is currently highly centralized, with large labs running bioassays that are often optimized for automation, throughput, and cost rather than robustness and ease of use in the field, and rapid delivery of results. This project proposes to decentralize some of those tests, and move them to the patient and point of care.

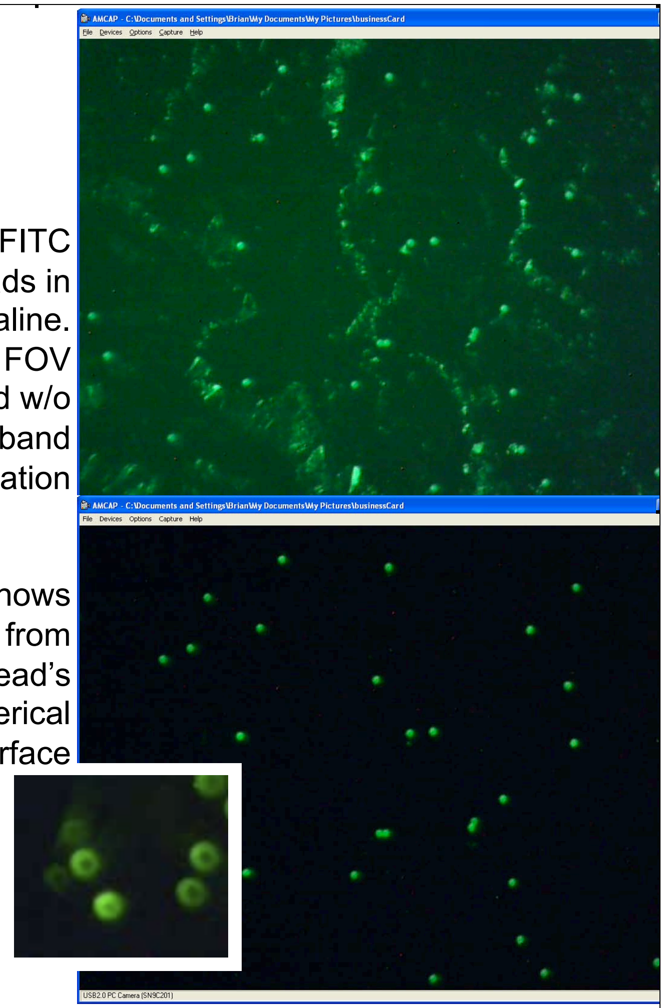
Challenges and problems:
1. **Identify best assays**. Explore which medical assays are most amenable and most valuable to decentralize and bring to the patient. Assays amenable to fluorescence imaging include HIV, malaria, cancers, parasites, etc.
2. **Design assays.** Prototype and validate tissue preparation, biochemistry protocols, and imaging protocols for those assays, which are robust, simple, and cheap enough to be viable in the target environment.
3. **Design a business model**. What is the ROI on the microscope, and how cheap does it have to be? What is the cost of the assay and how does it compare to current costs? What value are the results? To whom? How do we quantify the value of a medical diagnosis? Who will pay for the value?
4. **Plan a sustainable enterprise** to sell and support such enhanced point-of-care medical capabilities. What can we learn from related projects, such as barefoot doctors in India? How can surplus money support research developing additional assays and applications?
5. **Optimize design** of the microscope hardware and software, identifying key user interface issues and potential barriers to adoption.

Epifluorescence Microscope



10 μm FITC beads in saline. Same FOV with and w/o broadband illumination

Zoom shows light is from bead's spherical surface



Webcam based fluorescent microscope proof-of-concept. Left: A <$10 webcam sits below an epifluorescence filter cube, illuminated by an ultrabright LED powered by a 9V battery (front). An inverted security camera lens (<$5) produces an image with resolution ~1 micron per pixel, clearly resolving the spherical structure of the10 micron fluorescent beads (inset, right bottom). (Red blood cells are ~5 micron diameter.) Right: top and bottom are same field of view of 10 micron fluorescent beads in dried saline. Salt crystals and debris that scatter ambient light (top) disappear when illuminated solely by the microscope's blue LED (bottom).