SP.722 (D-Lab) Spring 2005
Session #27 notes

Affordable Eyeglasses

Lecturer: Saul Griffith. MIT alumnus, winner of numerous invention awards. See bio at http://www.squid-labs.com/people/saul.html.

If you visit a country like Nepal, you may notice how few people wear eyeglasses compared to the U.S. It's not because they all have perfect eyesight.

Of 5B+ people in the world, 1B need and have glasses, and 1B need and don't have glasses. Most who don't have them can only afford a few dollars, i.e. $5.

Interesting notes:

- In Africa, only 10-15% need glasses;
- In Singapore, over the past couple of decades the percentage needing glasses has skyrocketed. Why? (One theory is that kids are studying many hours at a young age.)

WHO estimates the "economic damage" due to uncorrected vision exceeds $75B/yr – for example, you need reading glasses but can't afford them, which severely limits your job opportunities.

In high volume manufacturing, lenses cost ~$2 per pair, but this is just a fraction of the true cost of delivering suitable prescription eyeglasses. Two technology barriers contribute to the high cost:

1. the cost of vision testing -- especially cost of training and paying the optometrist; and
2. the cost of shipping and inventory in less developed regions.

To reduce the cost of vision testing, Saul has developed a low-cost auto-retinoscope. To break down the shipping and distribution barriers, he's developed a novel system to manufacture eyeglasses "in the field."

Low-Cost Vision Testing

This system uses goggles containing an LED photodetector array and some relatively simple computing logic. The patient puts the goggles on for a moment and the system determines the prescription automatically. His company just got a small business grant from NIH to refine and bring to market soon. The initial stage of this grant is only $100k, whereas full-blown machined and manufacturing-ready system will take several million dollars minimum…but it's a start.

Saul notes that he did most of the work on this system within the project work of various MIT classes, i.e. Alex Slocum's Precision Machine Design course.[1]

There are myriad "protectionist" laws and regulations about who can prescribe glasses and test vision. In South Africa, it's illegal to sell glasses for less than $80 (a legacy of apartheid). On the other hand, Indonesia has thoroughly deregulated vision care, and you can get glasses from a street vendor for about $1.50, hand ground and maybe accurate to within a diaopter.

Obviously, the optometry profession will view this as a threat. For now Saul has to ignore these barriers, position it as a screening device not capable of actually generating a prescription, assume that social and policy changes will come if the machine is good enough.

Low-Cost Eyeglasses Manufacturing

Saul gives a demo of his lens molding system. It's a "very expensive precision coffee can", filled with baby oil, and topped by a sheet of metallized mylar – sealed and connected via tubing to a large syringe. Pull the syringe back, and the suction pulls the membrane down and creates a lens. This particular demo shows that the lens can even have a dual focal length (bifocal) capability.

Who needs glasses? The range of vision correction ranges from -8 to +12 diopters, and once you're off 0.25 from "normal," you could benefit from glasses. In conventional vision testing, the optometrist would have a series of test lenses with different corrections, broken into 0.25 diopter intervals (minimum difference that most people can resolve). Covering -8 to +12 diopters, that's 80 different test lenses. With astigmatism, the eye has one capability along the horizontal axis and a different capability on the vertical axis; that's 80 steps along horizontal x 80 steps along vertical, or ~5,000 different test lenses. A 1 hour glasses shop actually has this many molds in its manufacturing inventory. (And this is oversimplifying; there are several other conditions like presbyopia (need for bifocals) that create a "5 axis" problem space.)

With Saul's invention, he can continuously vary the correction across both axes to create any lens required. Lay a liquid acrylic monomer on the membrane, hit it with UV light for ~3 minutes, and you've got a lens.

Q: What's your perspective on the relative importance of low cost testing vs. low cost lens manufacture?
A: In a world where FedEx can deliver packages nearly anywhere overnight, Saul's hunch is that low cost testing will have more lasting impact.

Q: How do you fund this research?
A: Lots of stakeholders in vision correction see these inventions as threatening to their businesses and "turf."

[1] See Mechanical Engineering course 2.75 in MIT OpenCourseWare (http://ocw.mit.edu).

Presbyopia (corrected by bifocals) is a disease of affluent societies. In other words you have to live a long time for this condition to happen. It turns out that 90% of the profit in the eyecare industry is from this "high functionality" lens. When you take all the presbyopia variations into account, you need essentially an infinite number of lens molds.

This project offers lessons in how to get funding (bringing other agendas into the mix), yet still get the important work done. To solve the presbyopia-correcting lens manufacturing problem, he's working on a finely-spaced matrix of electrically controllable wires or piezos that controls the contour of the membrane. Saul's expectation is that the "high end" funders of this work will get what they need, while Saul retains enough control over fundamental IP that he can adapt for his low-cost global targets.

Optometrist density (per capita) has a tremendous influence on the potential impact of this solution. In the US, it's one optometrist per 8K; in rural Nicaragua, one optometrist per 270K. Currently, one can buy glasses in Nicaragua for about $50, of which $3 is cost to manufacture in China, $11 is for the local lab, and $40 is overhead and profit for the "local" retailer (not local for most people).

Saul's delivery model for a country with very few optometrists? Outfit a person on a motorcycle, testing kit in one side pannier and the lens manufacturing kit in the other side, with a target capital cost of "several thousand dollars."

Q: What about recycled eyeglasses programs? What happens when you donate your old glasses?
A: These programs don't help as much as people might wish. In a typical scenario, glasses are shipped to a prison in Texas, where somebody is paid about 9 cents/hr to sort through the lenses. They test on a donated machine that may not be very accurate, write the prescription by hand on lens/bag, and toss into a box for shipping. There's no organization. In the target country, a patient walks in with a particular need. Among the thousands of potential prescriptions, if you're really lucky you can find a pair of lenses to match…but then your patient is probably an 18 yr old male, and you could only match the prescription with 70s-vintage Farah Fawcett style lenses with rhinestones. Guess what? He won't take them…