The HPU: Human Processing Units

Prof. James Davis
Computer Science, UC Santa Cruz

function HPU (RGB *image, char *instructions) {

}
Computer vision

Poverty
Computer vision
Top google image search results ‘computer vision people tracking’
Parasitised red blood cells: 
*P. Falciparum* trophozoites
Human co-Processing Units (HPUs)

I'm not so fast at mathematical calculation. Fortunately I have a vast array of computers to help.

I'm not so good at visual pattern matching. Fortunately I have a vast array of humans to help.
HPU based NASA Computers at work in 1949 [Photo-E49-54]
Human Processing Unit

~1950

CPU

~2000

GPU

~2010

HPU
## Core of computer science

- Abstract interfaces
- Large systems from building blocks

<table>
<thead>
<tr>
<th>Toolbox libraries</th>
<th>Toolbox libraries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matlab</td>
<td></td>
</tr>
<tr>
<td>C++</td>
<td></td>
</tr>
<tr>
<td>Compiler</td>
<td></td>
</tr>
<tr>
<td>Assembly</td>
<td></td>
</tr>
<tr>
<td>Machine language</td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td></td>
</tr>
<tr>
<td>CPU</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Turk</td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td></td>
</tr>
<tr>
<td>HPU</td>
<td></td>
</tr>
</tbody>
</table>
Labor as cloud computing

- Amazon Mechanical Turk
- Crowdflower
- Samasource
- CloudCrowd
- txtEagle
- oDesk
- eLance
function what_color (RGB *image) {
How do they compare?

**CPU**
- $20,000+$36/mon

**HPU**
- $5,000+$675/mon
  - + shorter dev time
  - + higher accuracy
  - + 20% increase per visitor revenue
Accuracy of bar codes from cell phone cameras
<table>
<thead>
<tr>
<th>Method</th>
<th>Easy (%)</th>
<th>Hard (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPU/CPU</td>
<td>100%</td>
<td>83%</td>
</tr>
<tr>
<td>HPU</td>
<td>92%</td>
<td>60%</td>
</tr>
<tr>
<td>CPU Gallo</td>
<td>98%</td>
<td>54%</td>
</tr>
<tr>
<td>CPU Tekin</td>
<td>95%</td>
<td>6%</td>
</tr>
<tr>
<td>CPU DataSymbol</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>CPU DTK</td>
<td>98%</td>
<td>3%</td>
</tr>
<tr>
<td>CPU OCR</td>
<td>59%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Core of computer science

- Abstract interfaces
- Large systems from building blocks

<table>
<thead>
<tr>
<th>Toolbox libraries</th>
<th>Toolbox libraries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matlab</td>
<td></td>
</tr>
<tr>
<td>C++</td>
<td></td>
</tr>
<tr>
<td>Compiler</td>
<td></td>
</tr>
<tr>
<td>Assembly</td>
<td>Mechanical Turk</td>
</tr>
<tr>
<td>Machine language</td>
<td>Human</td>
</tr>
<tr>
<td>Hardware</td>
<td>HPU</td>
</tr>
<tr>
<td>CPU</td>
<td></td>
</tr>
</tbody>
</table>
I’m trapped in a box. Get me out of here!

Human cost?
Computer vision

Poverty
Poverty [pov-er-tee]
The state of condition of having little or no money
“In the box” is a good job!

Business process outsourcing $1/hr

Rural work $0.25/hr
Survey Amazon Mechanical Turk Workers in India

- 40% of workers in India
- 60% educated in English
- 91% w/some college
- 92% have a PC at home

“When I found mturk, it changed my life. It helped me a lot”

“It is my full time profession. I don’t have any other income sources”
So what is limiting growth?
User study to understand ability to use AMT

- 49 Participants from Indian working class
- US$133/month average income
- 12 grade education
- Computer literacy
- No prior MTurk experience
0% Completion
Draw a bounding box around the following object in the image:

**banana** - elongated crescent-shaped yellow fruit with soft sweet flesh

**Instructions:**
- Include all visible parts and draw as tightly as possible.
- If there are multiple instances, please only ONE (any one).
- Do NOT draw on instances that already have bounding boxes.

**Optional** Enter any comment you have:

Report this HIT: violates the Amazon Mechanical Turk policies or [julien](mailto:Why?):
(Translate to Kannada)

0% Completion
<table>
<thead>
<tr>
<th>Participant</th>
<th>Time required to submit 20 tasks</th>
<th>Payment for 20 tasks</th>
<th>Expected hourly payment</th>
<th>Net hourly earnings (with low cost of access)*</th>
<th>Net hourly earnings (with high cost of access)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fastest participant</td>
<td>3:33</td>
<td>$0.05</td>
<td>$0.85</td>
<td>$1.62</td>
<td>$0.40</td>
</tr>
<tr>
<td>Median participant</td>
<td>8:15</td>
<td>$0.05</td>
<td>$0.36</td>
<td>$0.64</td>
<td>-$0.08</td>
</tr>
<tr>
<td>Slowest participant</td>
<td>23:49</td>
<td>$0.05</td>
<td>$0.13</td>
<td>-$0.10</td>
<td>-$0.32</td>
</tr>
</tbody>
</table>

* $0.22 (Rs. 10) per hour of PC + Internet access
** $0.44 (Rs. 20) per hour of PC + Internet access

AMT Work @ 36¢ /hr <-> Average Pay @ 55¢ /hr
Computer vision

Poverty

Human Processing Unit
Computer vision

Poverty

Business
People to people outsourcing is a $500B market
Computer to people outsourcing …
Human Processing Unit

CPU → GPU → HPU

~1950 → ~2000 → ~2010
Acknowledgements

Funding: NSF, LANL
Collaborators: MSR India and many students
Poverty [pov-er-tee]
The state of condition of having little or no money
Is this for real?
function what_color (RGB *image) {
    HPU(image, "What color is the shoe in this image?")
}
function what_color (RGB *image) {
    HPU(image, "What color is the shoe in this image?"
