Lecture 3:
CS 6306 / INFO 6306: Advanced Human Computation
Today: Games with a Purpose (overt)

• Required readings:

• Additional readings:
  - Cooper, Seth, ... "Predicting protein structures with a multiplayer online game." *Nature* (2010).
  - Tuite, Kathleen, Nadine Tabing, Dun-Yu Hsiao, Noah Snavely and Zoran Popović. "PhotoCity: training experts at large-scale image acquisition"
FoldIt
FoldIt

But first, “citizen science”
Citizen Science

• "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions“ – *Oxford English Dictionary*

• History:
  - Often a pastime/hobby for the wealthy – “gentleman scientist”
  - Examples:
    • Astronomy: 1781 - William Herschel (while a musician) discovered Uranus in 1781
    • Archaeology: 1781 - Thomas Jefferson’s systematic excavation of a Native American burial mound in 1781
    • Meteorology: 1823 - Meteorological Society of London founded in 1823 “to receive meteorological observations from the cultivators of science…”
    • Meteorology: 1890 - US National Weather Service Cooperative Observer Program
    • Ornithology: 1900 - Audubon Society Christmas Bird Count
    • Entomology, botany, zoology, oceanography, etc.
    • Oxford English Dictionary: 1857
  - Development of “citizen sensor” approach
Citizen Science

• Today: Refers to both Internet-based efforts and local citizen science efforts (such as in schools)
• Three general modalities:
  • “Citizen sensor” – often on very large scales
  • STEM education
  • Collaborators/scientists
Prominent Internet-based Citizen Science Projects

• FoldIt:
  • Video game for protein folding
  • 300,000 players
  • Science outcomes:
Prominent Internet-based Citizen Science Projects

• FoldIt:
  • Video game for protein folding
  • 300,000 players
  • Science outcomes:
Prominent Internet-based Citizen Science Projects

• Galaxy Zoo:
  • Astronomical image labeling
  • 250,000 users
  • Science outcomes: 48 domain-science papers
  • Spawned the Zooniverse platform (46 domain-science papers)
Prominent Internet-based Citizen Science Projects

• EyeWire:
  • Mapping neurons in images
  • 200,000 players
  • Science outcomes:
Prominent Internet-based Citizen Science Projects

• Phylo:
  • Video game for multiple sequence alignment
  • Science outcomes:
Prominent Internet-based Citizen Science Projects

• Eterna:
  • Video game for RNA folding
  • “tens of thousands of players”
  • Science outcomes:
Science of Citizen Science: FoldIt, Eterna

• FoldIt:

• Eterna:
Science of Citizen Science: Zooniverse

- Why Won’t Alien’s Talk to Us: Content and Community Dynamics in Online Citizen Science, 2014.
- “I want to be a Captain! I want to be a Captain!”: Gamification in the Old Weather citizen science project, 2013.
- Creativity in citizen cyberscience: All for one and one for all, 2013.
FoldIt

• Original Game:
  • Players twist proteins into shapes through direct manipulation tools
  • The quality of a shape is assessed by existing programs
  • Chemically important elements given visual cues, like colors
  • Technical terms replaced with more familiar words
  • Players are taught by advancing through levels

• Why humans:
  “We hypothesized that human spatial reasoning could improve both the sampling of conformational space and the determination of when to pursue suboptimal conformations if the stochastic elements of the search were replaced with human decision making while retaining the deterministic Rosetta algorithms as user tools.”
FoldIt

• Assessment: New science outcomes:
FoldIt

• Why should humans outperform computers?
  • “human ability to search over the space of possible strategies and adapt
    those strategies to the type of problem and stage of problem solving”
  • “The variability of tactics and strategies stems from the individuality of each
    player as well as multiple methods of sharing and evolution within the game
    (group play, game chat), and outside of the game”

• Learning how people solve these problems
  • Machine learning: Banerji, Manda, Ofer Lahav, Chris J. Lintott, Filipe B.
    Abdalla, Kevin Schawinski, Steven P. Bamford, Dan Andreescu et al. "Galaxy
    Zoo: reproducing galaxy morphologies via machine learning." *Monthly Notices
  • Human computation: Khatib, Firas, Seth Cooper, Michael D. Tyka, Kefan
    Xu, Ilya Makedon, Zoran Popović, and David Baker. "Algorithm discovery
    by protein folding game players." *Proceedings of the National Academy
FoldIt

- Formulating algorithms – both science outcomes and assessment
  - Build off of FoldIt’s ability to codify “recipes”:
    - “We augmented standard Foldit play with the ability to create, edit, share, and rate gameplay macros, referred to as “recipes” within the Foldit game”
  - 568 players wrote 5,202 recipes
  - 721 Foldit players ran 5,488 unique recipes 158,682 times
  - Four categories:
    - perturb and minimize: add noise to avoid local minima
    - aggressive rebuilding: rebuild large regions (long run times)
    - local optimize: local minimization of a region
    - set constraints: adds constraints between residues or regions or tweaks secondary structure to influence optimization
  - Augment human effort by codifying low-level routines
    - Use always guided by human
    - Success requires human contributions
Assessment: History of Recipe Usage
Assessment: History of Blue Fuse Recipe Creation
Assessment: Compared to Programs

• Same style developed independently by domain scientists
Assessment: Compared to Programs
Assessment: Compared to Programs
Assessment: Compared to Programs
Assessment

• Solved problems computers couldn’t
• Outcomes in use by players
• Comparable to programs and people
PhotoCity

• Motivation:
  • 3D reconstruction of scenes from photos requires photos (diverse, numerous)
    – 50 per building
PhotoCity

• Motivation:
  • 3D reconstruction of scenes from photos requires photos (diverse, numerous)
    – 50 per building
PhotoCity

• Goals:
  • Get players to take photos
  • Direct players to “gaps and fringes” in a partial reconstruction

• Only a few dozen players!
PhotoCity Game Play

- Capture flags for your team and conquer buildings for yourself!
- Go outside and take pictures of buildings where the flags are.
- Look for flags on our map at our website, or on our iPhone app.
- Add pictures to flags on our website or through our iPhone app.
PhotoCity Elements

• “Seed” reconstructions vetted by designers (20-200 photos)
• Models are dense point clouds (thousands of points)
• Photos add points to the model
• Players get points for taking pictures of flags:
  • Must overlap with existing points in the structure
    • Validates photos
  • Must overlap with an empty space
    • Adds to a model
  • Players get one point for each point added to the model
• Capture flags at buildings by getting more points at the flag
• Capture buildings by getting more points at the flag
• (Upload photos via app or manually)
PhotoCity: Motivating Players

• Used theory from R. Bartle. *Designing Virtual Worlds*. New Riders Games, 2003 – 4 types of players:
  • Explorers
  • Achievers
  • Killers
  • Socializers

• Wanted to appeal to all of them

• Paid attention to rendering the game/models effectively
PhotoCity: Gaming Elements

• Teams:
  • Cornell vs UW
  • Red, green, blue, yellow

• Individual:
  • Leader boards
  • Titles (most models, flags, seeds, recruiting)
  • Prizes
  • Collectible gems (first player gets it)
PhotoCity: Outcomes

• 60% of photos are used in models (compared to 10% for Flickr-based project)
• 80% of photos from top 10 players
  • Top player responsible for 20% of photos
• Much denser coverage of campuses than Flickr
• Ratio of good/bad photos similar for “pro” and “non-pro” photographers
• Got to know campus
# PhotoCity: Outcomes

<table>
<thead>
<tr>
<th>Model</th>
<th>Starting Photos</th>
<th>Starting Points</th>
<th>Ending Photos</th>
<th>Ending Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE Front Entrance</td>
<td>58</td>
<td>18,131</td>
<td>515</td>
<td>148,189</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>30</td>
<td>13,133</td>
<td>1,230</td>
<td>380,102</td>
</tr>
<tr>
<td>James J. Hill Statue</td>
<td>48</td>
<td>51,461</td>
<td>406</td>
<td>224,783</td>
</tr>
<tr>
<td>Southeast Corner of CSE</td>
<td>27</td>
<td>9,597</td>
<td>935</td>
<td>304,030</td>
</tr>
<tr>
<td>Fountain-facing Corner of EE</td>
<td>68</td>
<td>38,439</td>
<td>979</td>
<td>321,805</td>
</tr>
<tr>
<td>Commodore Apartments</td>
<td>41</td>
<td>9,973</td>
<td>581</td>
<td>66,777</td>
</tr>
<tr>
<td>Allen Library</td>
<td>92</td>
<td>28,945</td>
<td>840</td>
<td>131,558</td>
</tr>
<tr>
<td>Engineering Library</td>
<td>74</td>
<td>8,598</td>
<td>584</td>
<td>62,095</td>
</tr>
<tr>
<td>Guggenheim</td>
<td>101</td>
<td>85,239</td>
<td>1,394</td>
<td>622,355</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>46</td>
<td>27,022</td>
<td>741</td>
<td>273,889</td>
</tr>
<tr>
<td>Mary Gates (West Side)</td>
<td>32</td>
<td>36,891</td>
<td>1,488</td>
<td>761,777</td>
</tr>
<tr>
<td>Suzzallo Library</td>
<td>41</td>
<td>36,566</td>
<td>1,526</td>
<td>492,871</td>
</tr>
<tr>
<td>Hing Hay Park*</td>
<td>73</td>
<td>46,965</td>
<td>116</td>
<td>54,333</td>
</tr>
</tbody>
</table>

*Seed added by player during trial
Is this human computation?
Next Time: Programming Languages

• Required readings:

• Additional readings: