



Citizen Engineering: Evolving OSS Practices to Citizen Engineering Design and Analysis

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Overview

- » From *OSS* to *Citizen Engineering* (CE)
- » CE: 6 major categories
- » Ongoing Research
 - Study I: Earthquake Photo Tagging
 - Study II: Infrastructure Photo Sensing
 - Study III: Shelters For All Competition
 - Study IV: Expert-Citizen Experiment
 - OpenFOAM Simulation
- » Summary and Future Work

NSF Project

Open Sourcing the Design of the Civil Infrastructure (OSD-CI)

Engineering Research – Learn by Prototyping
How to ensure Highly Trustworthy Results?
Motivation?
Skill Level?
Evaluation?

What Can Engineering Disciplines Learn from OSS?

Idea 1: Human-Based Computation

- » First computers were humans
- » Cognitive Surplus, (Shirkey, 2010)
 - > Potential for thousands of Wikipedias each year
 - > Maslow's self actualization, etc.
- » Phenomenon: Individual citizens self-organize to create, to solve problems, to perform meaningful tasks, ...
 - > Wikipedia (Citizen Encyclopedia Authors!)
 - > Citizen Science
 - > Citizen Journalism
 - > Free Libre Open Source Software (Citizen Software Engineering!)
 - > Citizen Engineering
- » Crowd sourcing, click workers, human computing, social computing, etc

Idea 2: OSS is Citizen Engineering

- » OSS: Openness, distributed and often voluntary contributions, end-user participation.
- » CE: Online communities, physically and/or institutionally distributed users, large amount of small scale contributions.

- » OSS: Software Engineering Discipline
- » CE: Other Engineering Disciplines
Photo classification, Audio Transcription, Fundraising, Design, Failure Analysis, etc.

Citizen Engineering: 6 Categories

- » Crowd Decisions: Casting votes, e.g. reddit
- » Crowd Submission/Funding/Journalism/Media:
YouTube - Contents from the crowd
- » Crowd Wisdom/Knowledge:
Wikipedia – Knowledge from the crowd
- » Crowd Byproduct: Captcha/Recaptcha, Protein Folding Game
- » Micro Task: HITs on Amazon Mechanical Turk
- » Innovation Tournament: InnoCentive

Study I: Haiti Earthquake

Photo Tagging

Overview

- » Background: 2010 Haiti Earthquake
- » Thousands of Photos Taken on Site
- » CE Approach: Releasing Photos to Online Communities
- » 242 Citizen Engineers Participated
 - College Students as CE Surrogates
- » 9318 Photo Classifications on
 - 400 Sample Photos Over 17 days

Background

- » Goal:

 - Achieve highly trustworthy classifications from a large number of user inputs

- » Challenges:

 - Diversified user backgrounds

 - Potential malicious users

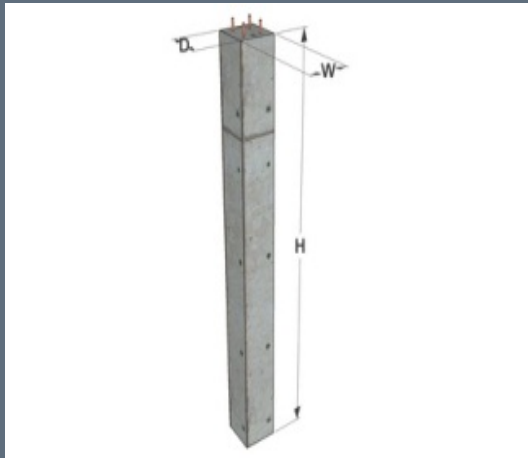
 - Large data size

- » Proposed Solutions:

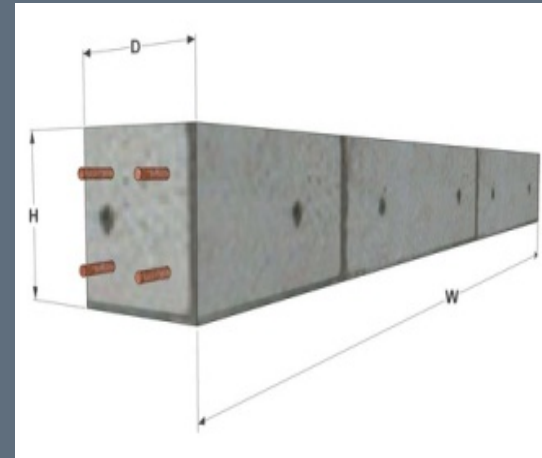
 - Statistical Tools to Prune Noise

Civil Engineering Failure Knowledge

Building Parts



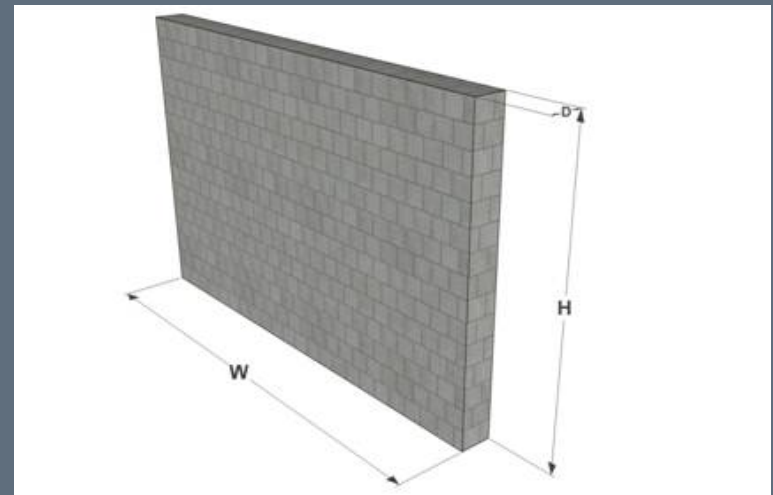
Column



Beam



Slab



Wall

Damage Type - Column



Damage Type - Beam



Damage Type - Slab



Damage Type - Wall



User Tasks:

Photo Tagging

Sample Question

Classify Photos

Number of Photos You Completed [?](#)

You've tagged 2 photos (1% of our database)

Your Standing in the Crowd [?](#)

You are in the 24th percentile (of all participants)



Is there damage in (any of) [the beam\(s\)](#)?

- Yes
- No

Is there damage in (any of) [the column\(s\)](#)?

- Yes
- No

Is there damage in (any of) [the slab\(s\)](#)?

- Yes
- No

Is there damage in (any of) [the wall\(s\)](#)?

- Yes
- No

[BACK](#)

[NEXT](#)

Clicking on links (underlined phrases in blue) will take you to the relevant page in the tutorial.

Typical Questions

Which **building** needs to be tagged?

- Tag entire photo
- Tag part of photo
- Cannot determine

BACK NEXT



What **primary elements** are visible and can be assessed in this photo?
(Check all that apply)

- Beam
- Column
- Slab
- Wall
- Cannot determine

BACK NEXT



Is there damage in (any of) **the beam(s)**?

- Yes
- No

Is there damage in (any of) **the column(s)**?

- Yes
- No

Is there damage in (any of) **the slab(s)**?

- Yes
- No

Is there damage in (any of) **the wall(s)**?

- Yes
- No

BACK NEXT



What **damage patterns** are visible in (any of) the beam(s)?
(Check all that apply)

- Flexure
- Shear
- Concrete Loss

What **damage patterns** are visible in (any of) the column(s)?
(Check all that apply)

- Flexure
- Shear
- Concrete Loss

What **damage patterns** are visible in (any of) the slab(s)?
(Check all that apply)

- Flexure
- Shear
- Concrete Loss

What **damage patterns** are visible in (any of) the wall(s)?
(Check all that apply)

- Sliding Shear
- Diagonal Shear
- Out-of-Plane



What is the **severity** of the worst damage pattern in (any of) the beam(s)?

- Yellow
- Red

What is the **severity** of the worst damage pattern in (any of) the column(s)?

- Yellow
- Red

What is the **severity** of the worst damage pattern in (any of) the slab(s)?

- Yellow
- Red

What is the **severity** of the worst damage pattern in (any of) the wall(s)?

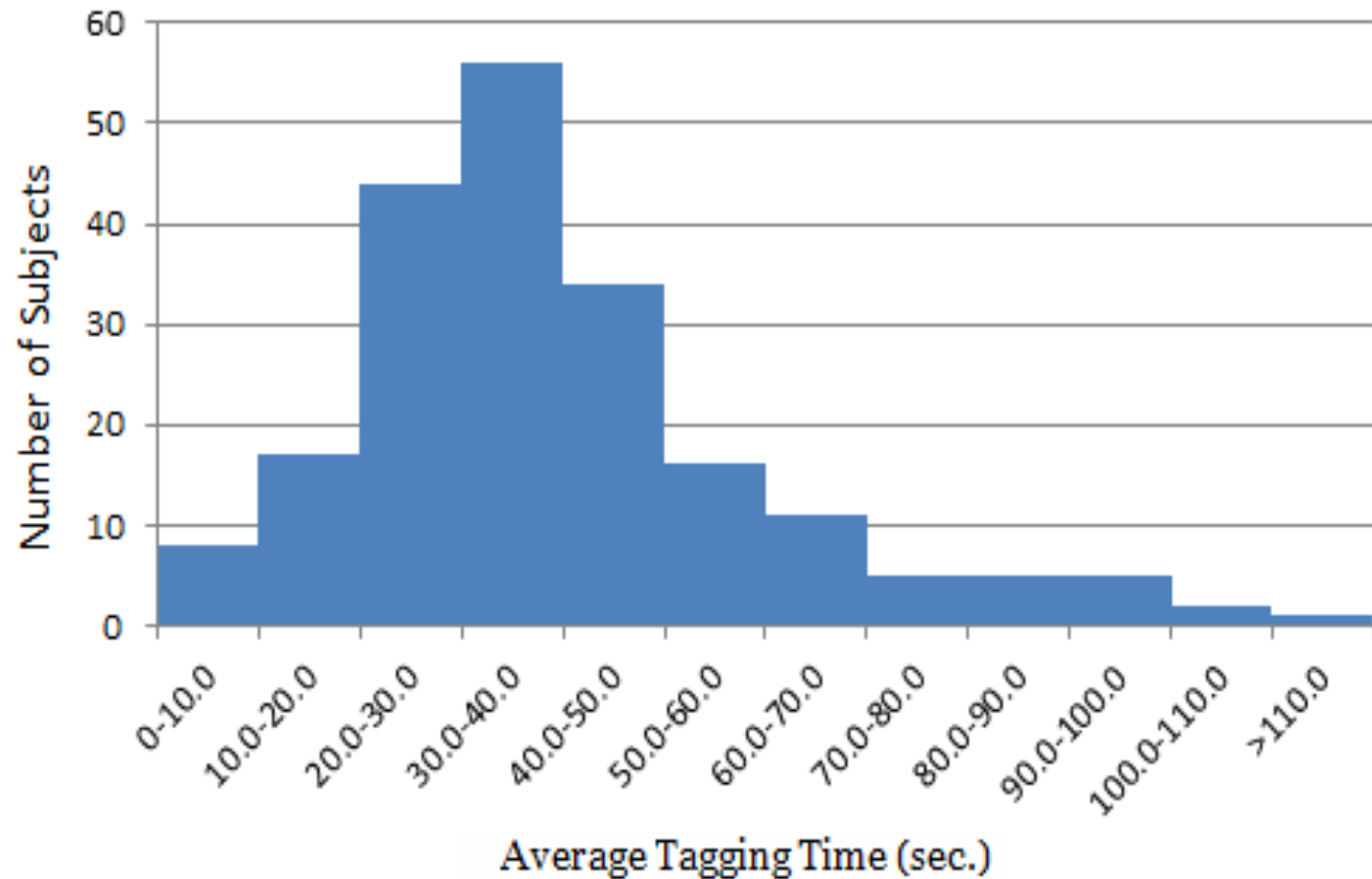
- Yellow
- Red

BACK NEXT

Post Experiment Data Analysis

Data Preparation - Cleaning

Freeloader: Average tagging time less than 13 sec.

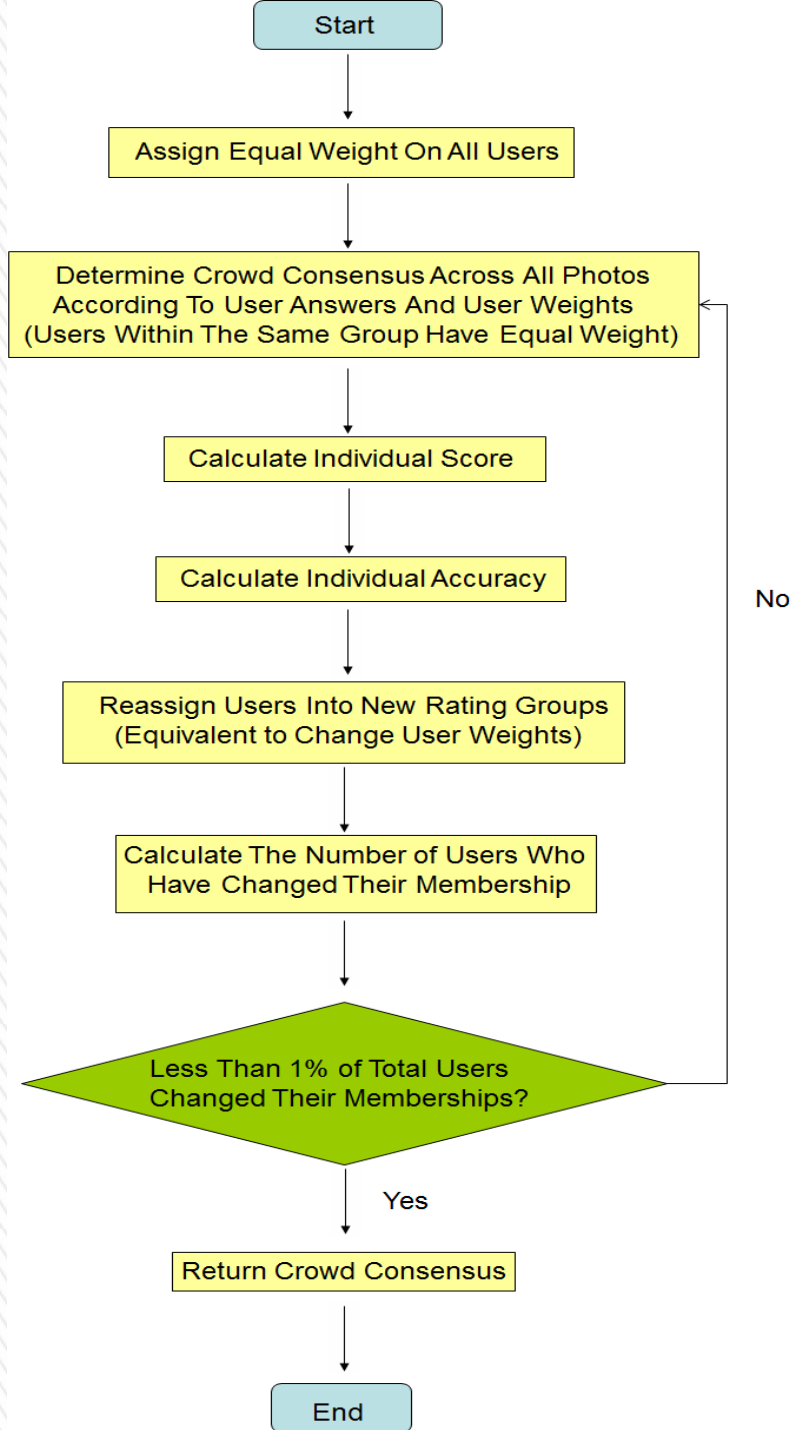


Data Preparation - Results

- » Before Data Cleaning
 - > 9318 user-image pairs (Classifications)
 - > 204 users

- » After Data Cleaning:
 - > 6186 user-image pairs (Classifications)
 - > 194 users

Algorithm



Summary

- » Contributions
 - > Web portal architecture
 - > Highly trustworthy result extraction
 - > Invalid inputs detection
 - > User motivation analysis

Study II:

Crumbling Infrastructure

Photo Sensing

Crumbling Infrastructure

» According to *American Society of Civil Engineers* (ASCE), the general condition of civil infrastructure in US is in a worrying situation.

2009 Grades

Aviation	D
Bridges	C
Dams	D
Drinking Water	D-
Energy	D+
Hazardous Waste	D
Inland Waterways	D-
Levees	D-
Public Parks and Recreation	C-
Rail	C-
Roads	D-
Schools	D
Solid Waste	C+
Transit	D
Wastewater	D-

America's Infrastructure GPA: **D**

Estimated 5 Year Investment

Need: **\$2.2 Trillion**

Tragic Accidents



I-35W Bridge in Minneapolis, Minnesota suddenly collapsed during the evening rush hour, in 2007.

Challenges

- » The amount of infrastructure in countries that cover a broad area, such as the USA, overwhelmingly exceeds the number of inspectors.
- » A more pervasive, efficient, and operable sensing mechanism empowering national level coverage is needed.

Citizen Engineering Solution



Digital Devices

GPS Tagging



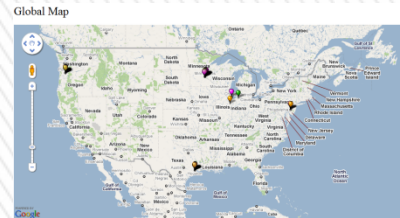
Yahoo API

Address Translation Web Portal



Google API

Photo Aggregation



Google Global Map

Advantages

- » Hand-held digital devices have pervasive coverage.
- » As a basic personal communication tool, cell phones have a relatively reliable power supply.
- » Digital device carriers' assistance could be leveraged to achieve sophisticated application functionalities.

Web Portal

[Home](#)[Tutorial](#)[My Account](#)[My Photos](#)[Upload](#)[Admin](#)[Logout](#)[Contact Us](#)

INFRASTRUCTURE PHOTOS

Statistics



User Statistics

Total Users	25
Users with Photos	8 (32%)
Without photos	17 (68%)



Photo Statistics

Total Photos	170
Photos with Geodata	168 (99%)
Without geodata	2 (1%)
Photos per user	6.8
Photos per active user	21.3



Admin



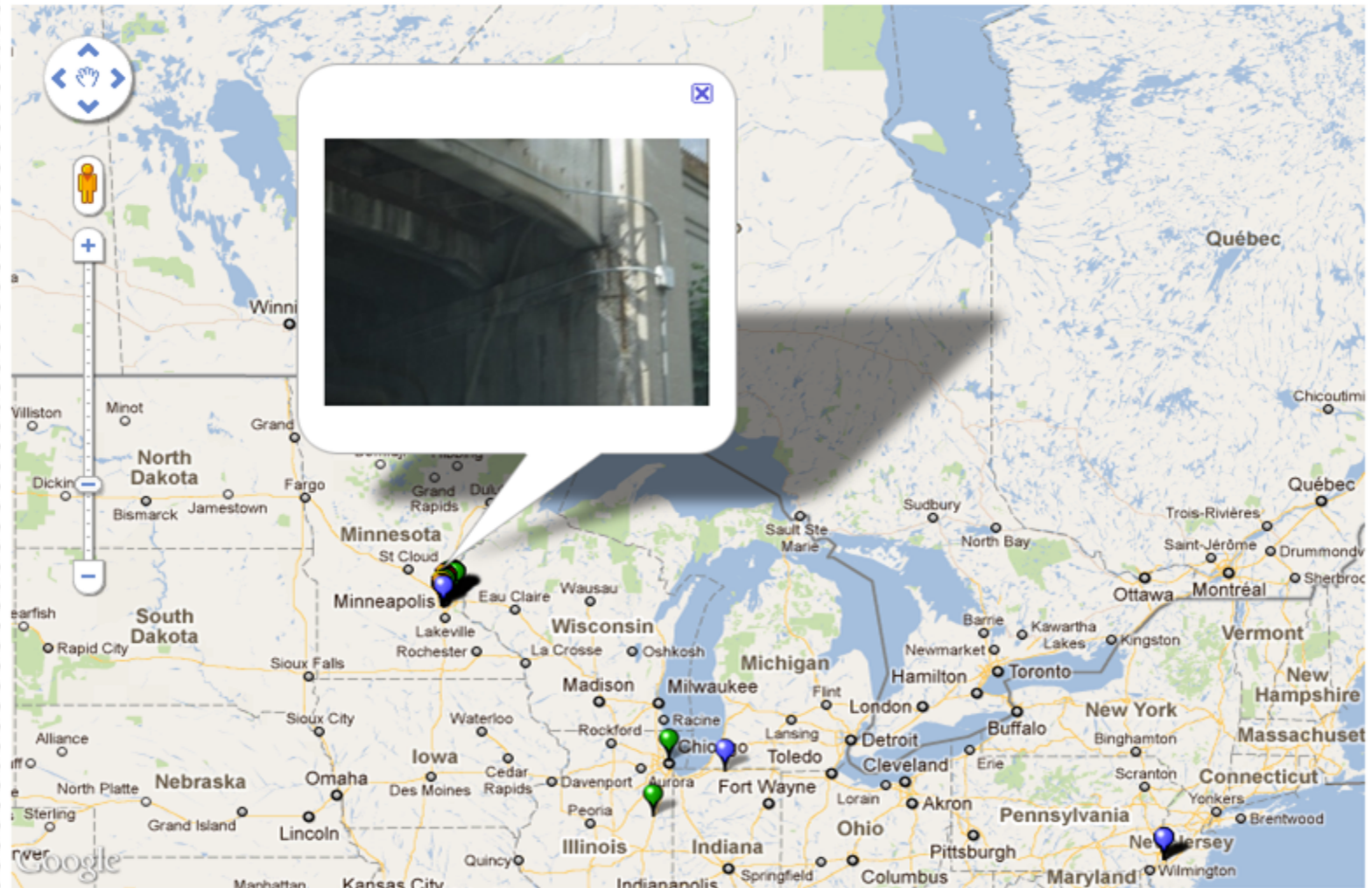
Global map



Statistics

Google Map Visualization

Global Map



Sample Photos

Minneapolis



Portland



Summary and Experiences

- » Users are generally interested in participating when they are assured that they can obtain benefit for themselves or a wider community.
- » The portal admins/data managers should ensure that the data sharing is controlled and that the privacy of the users is respected.

Study III:

Shelters For All Competition

Worrying Conditions

- » 15 of 20 most populated cities are in developing countries.
- » Over inhabited and unstructured settlements
- » Lack of safe water and proper sanitation

Project Design

- » Open to the world:
 - Soliciting solutions from the global citizens
- » Design Goals:
 - Low-cost, safe housing for the urban poor
- » 3 Types of Prize:
 - Best Design, Popular Vote, Most Referrals

A glimpse of User Account Page

Shelters for All

Harnessing the Wisdom of Crowds to Deliver Safe, Affordable
Housing to the World's Urban Poor

[Home](#) | [Logout](#) | [Admin](#)

[My Account](#)

[Team](#)

[Documentation](#)

[About Us](#)

[Blog](#)

[FAQ](#)

My Account

Account Progress

Entry Survey

Submission

Exit Survey

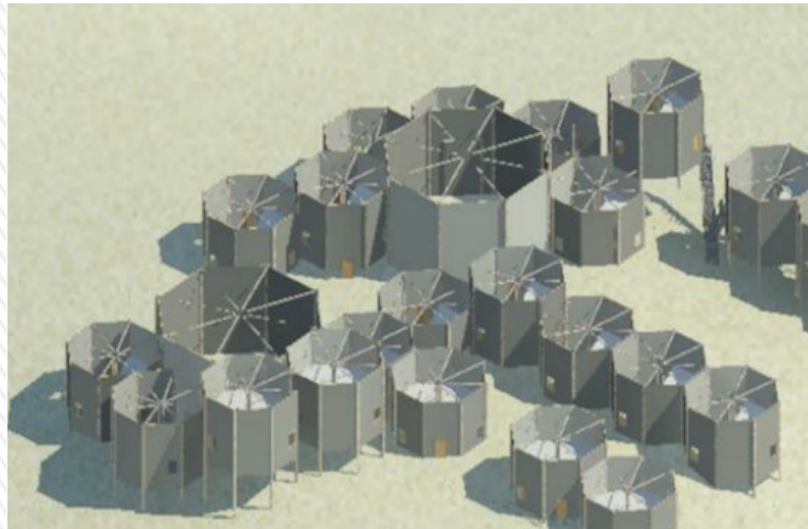
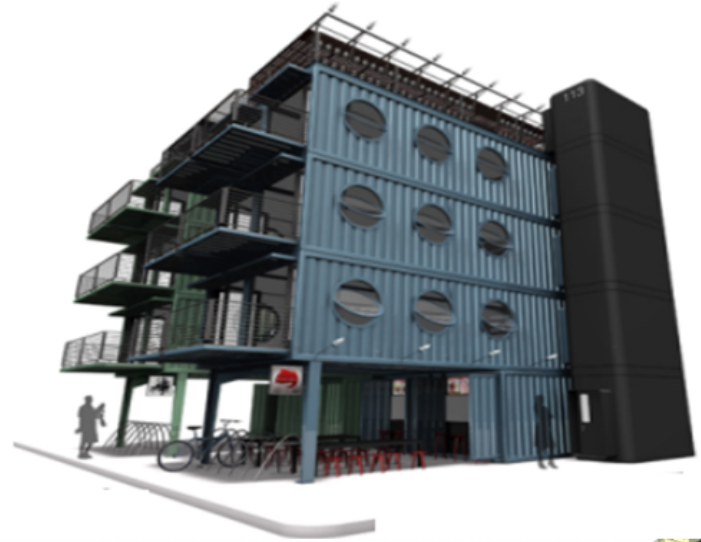
Peer Review

Submission
Repository

Results

- » 5909 visit sessions from 104 countries.
- » Visitors speak 58 different languages.
- » Countries that have the most visit sessions:
 - USA 2151 visits
 - UK 620 visits
 - Brazil 473 visits
- » Received 99 valid solutions from 26 teams and 73 individuals.
- » Peer evaluation
- » Expert evaluation

Sample Solutions



Study IV:

Expert – Citizen Experiment
OpenFOAM Simulation

Web Portal

OSD-CI Expert Citizen Engineer Experiment

[Home](#)[Login](#)

Welcome to the OSD-CI Expert Experiment

You are invited to participate in an online experiment run by the OSD-CI. If you decide to participate, we will ask you to login to a secure website, answer a few questions and take a brief tutorial.

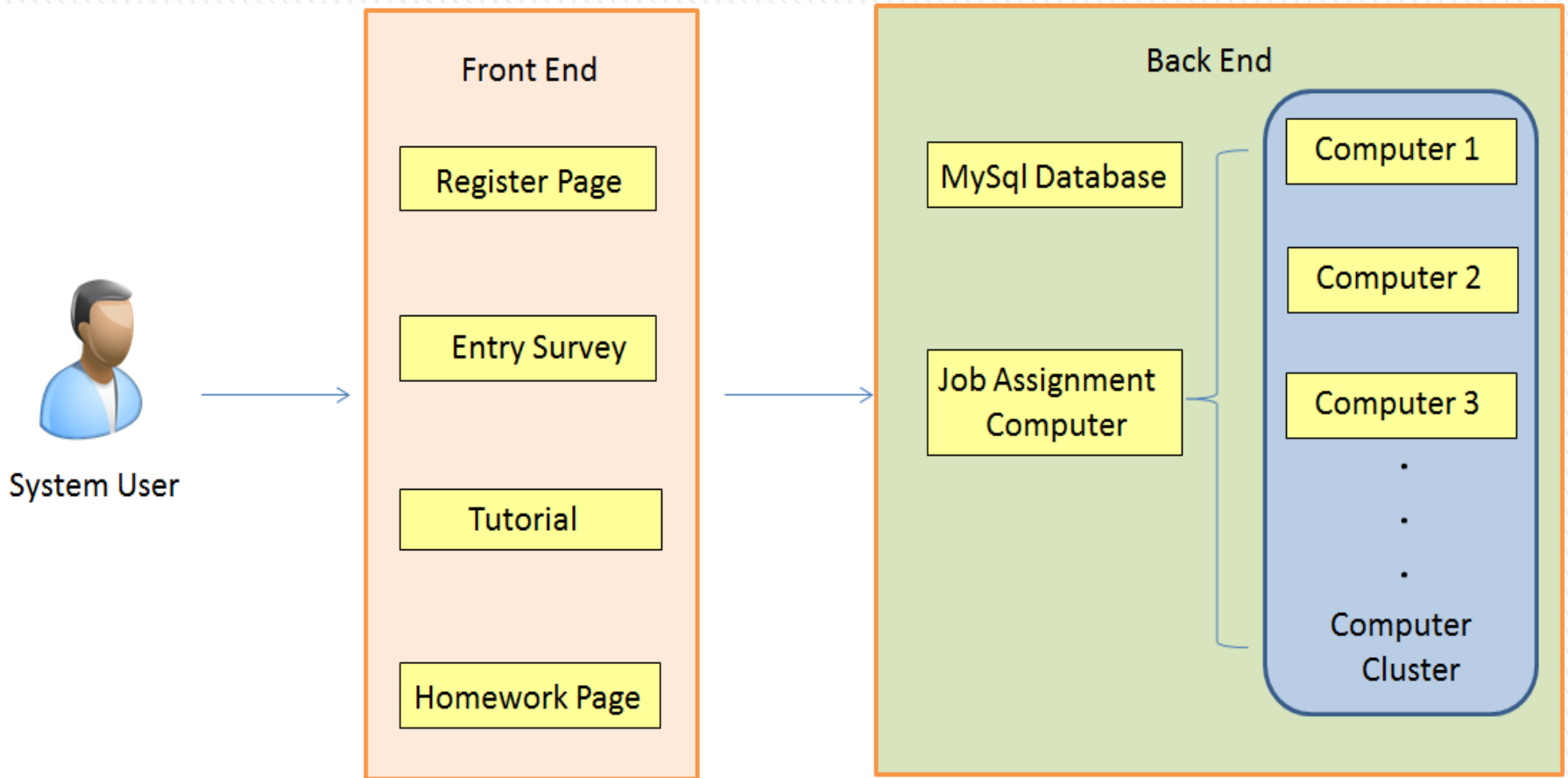
- **Prior to the tutorial, you will also receive information about additional benefits you may derive from participating in this experiment.**
- **If you choose to participate this experiment, it is important that you do not discuss the details of the study with others.**

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. BY CLICKING THE "I WOULD LIKE TO PARTICIPATE" OPTION YOU INDICATE THAT YOU ARE A NOTRE DAME STUDENT AND HAVE DECIDED TO PARTICIPATE HAVING READ THE INFORMATION PROVIDED ABOVE.

 [I would like to participate.](#)

 [I would not like to participate.](#)

Architecture



Tutorial

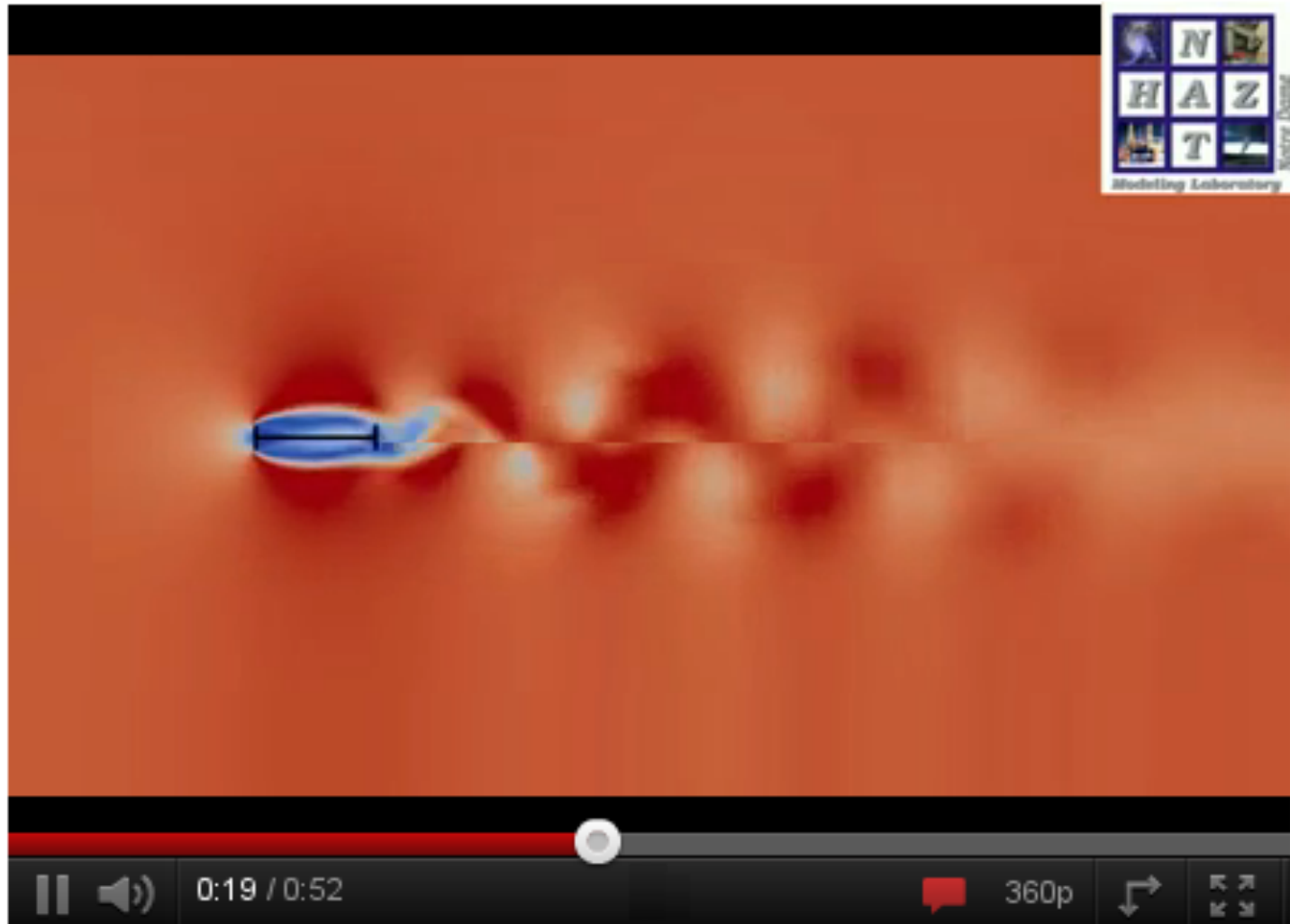
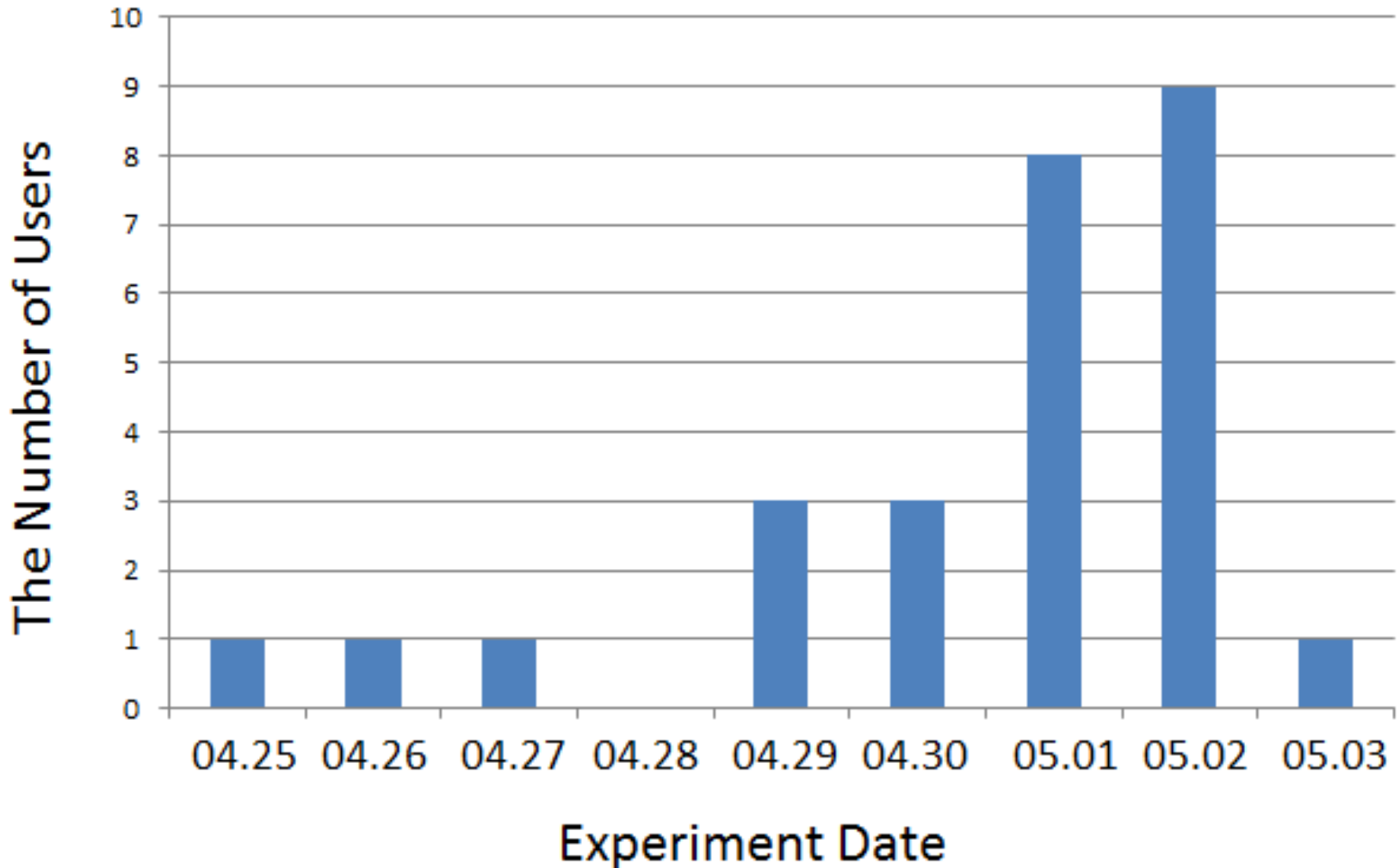
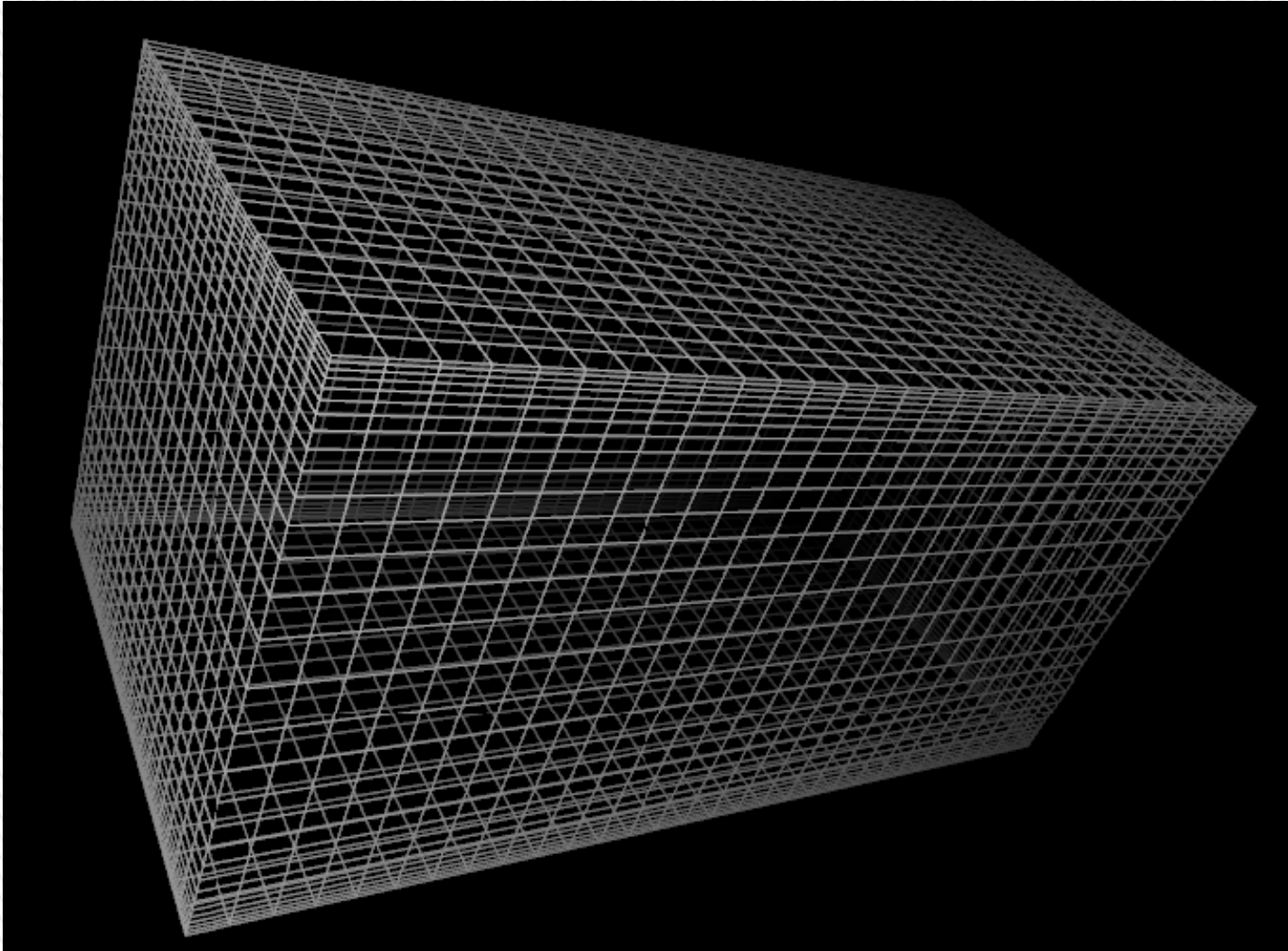


Photo of Courtesy: NatHaz Lab, Civil and Environmental Engineering
University of Notre Dame

User Statistics



Mesh Generation



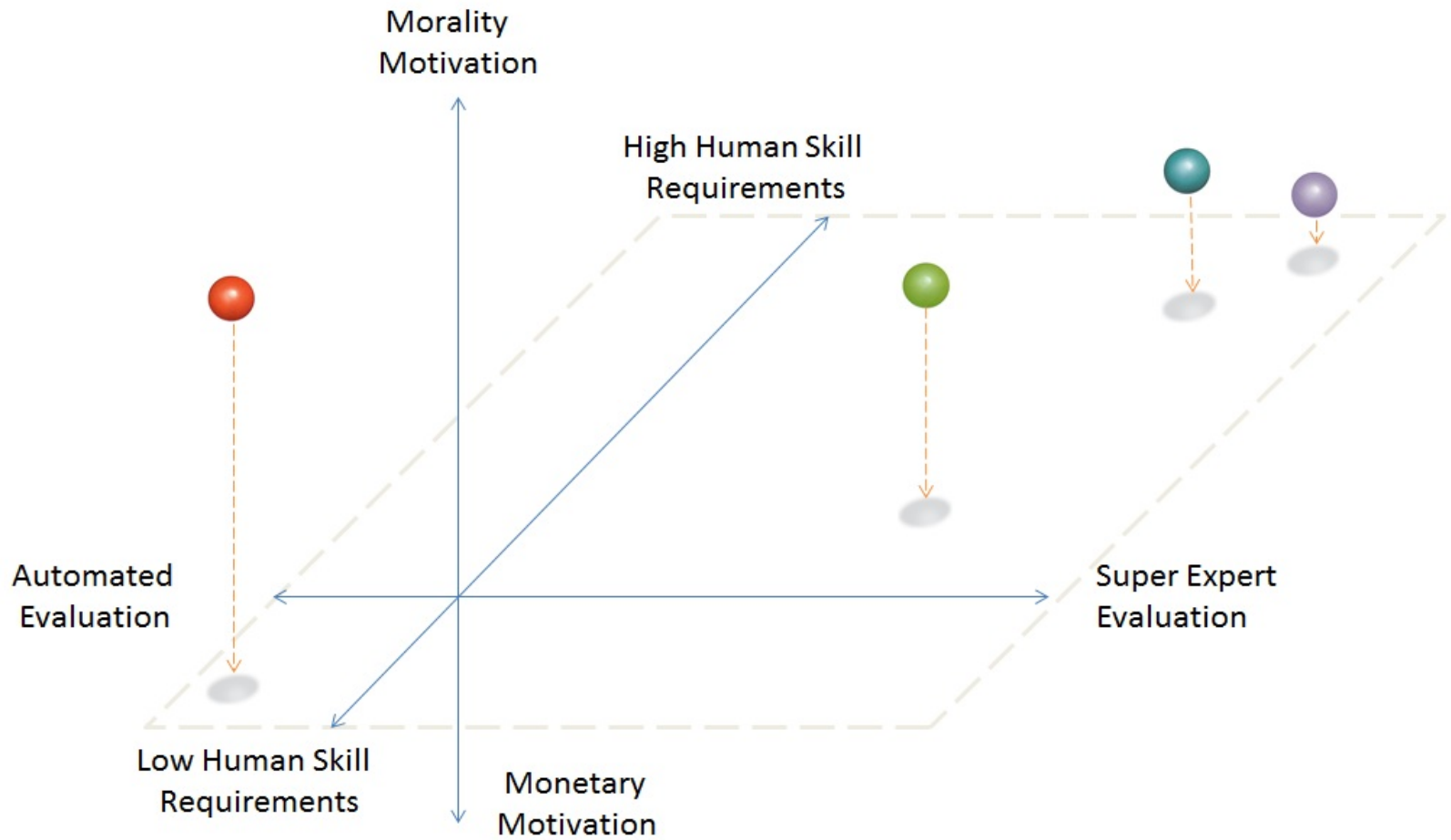
Summary

- » High-end users require high-performance computing facilities.
- » Innovative ways need to be developed to evaluate complicated tasks.
- » The platform needs to be prepared to take burst requests.

A Brief Summary of the Ongoing Research

A 3-Dimensional Classification

- » 1st Dimension: Contributor Motivations
Moral Motivations vs. Monetary Rewards
- » 2nd Dimension: Human Skills Required for the Task
The level of skills possessed by the workers
- » 3rd Dimension: Submission Quality Evaluations
The mechanisms to evaluate the user submissions



- Haiti Earthquake Photo Tagging : High Morality Motivation, Automated Evaluation, Low Human Skill Requirements.
- Smart Phone Infrastructure Monitoring: Medium Morality Motivation, High Expert Evaluation, Medium Human Skills.
- Shelters For All Competition : Mixed Motivation, Super Expert Evaluation, High Human Skill Requirements.
- OpenFOAM Simulation: Medium Morality Motivation, Super Expert Evaluation, High Human Skills Requirements.

Next Steps

- » Increase experimentation
- » Large engineering task with many sub-elements
- » Integration of sub-element steps into complete solutions



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