Supporting Cutting-Edge Synthetic Biology Research with Computational Innovations

WELLESLEY HCI

iGEM 2012
Our Vision

To apply engineering and HCI methodologies to promote collaboration and problem solving in the synthetic biology experimental process.
This time last year...
iGEM Feedback from Last Year...

I wish to view all the relevant information at once…

What if I don’t have a Microsoft PixelSense?

Where can I design my constructs?

I wish there were an interactive way to express the concepts behind Synthetic Biology…

How is your project addressing concerns in biosafety?
User-Centered Design
User Research

User-study

Low-Fidelity Prototype

Brainstorming

User Observations
Our Goals

Goal 1: Simplify the research and information-gathering process

Goal 2: Streamline the design and specification of complex constructs

Goal 3: Convey basic synthetic biology concepts to non-scientists
Our Projects

**SynBio Search**
Semantic search engine for synthetic biology information

**MoClo Planner**
A collaborative tool for Modular Cloning

**SynFlo**
An interactive installation teaching synthetic biology concepts to the next generation of synthetic biologists
Semantic search of Synthetic Biology information
Search Result for: gluten

Google Scholar results

Bba K590021: SynBio Datasheet | Parts Registry
http://partsregistry.org/Part:Bba_K590021
7: ...University of Washington] iGEM team to break down gluten, the primary cause of Celiac’s disease. To test...

Bba K590022: SynBio Datasheet | Parts Registry
http://partsregistry.org/Part:Bba_K590022
4: ...590021 Kumamolisin-Asj enzyme aimed to break down gluten by increased activity with the PQLP peptide, an a...7: ...University of Washington] iGEM team to break down gluten, the primary cause of Celiac’s disease. To test...

Bba K590023: SynBio Datasheet | Parts Registry
http://partsregistry.org/Part:Bba_K590023
4: ...590021 Kumamolisin-Asj enzyme aimed to break down gluten by increased activity with the PQLP peptide, an a...7: ...University of Washington] iGEM team to break down gluten, the primary cause of Celiac’s disease. To test...

Bba K590024: SynBio Datasheet | Parts Registry
http://partsregistry.org/Part:Bba_K590024
4: ...590021 Kumamolisin-Asj enzyme aimed to break down gluten by increased activity with the PQLP peptide, an a...7: ...University of Washington] iGEM team to break down gluten, the primary cause of Celiac’s disease. To test...

Bba K590087: SynBio Datasheet | Parts Registry
http://partsregistry.org/Part:Bba_K590087
4: ...590021 Kumamolisin-Asj enzyme aimed to break down gluten by increased activity with the PQLP peptide, an a...8: ...enzyme currently in clinical trials for treating gluten intolerance!

PubMed Early Childhood Infections and the Risk of Islet Autoimmunity: The Diabetes Autoimmunity Study in the Young (DAPS)
Authors: Snell-Bergeon JK, Smith J, Dong F, Bardin AE, Barriga K, Norris JM, Rewers M
Publication Date: 2012 Oct 5

PubMed Association of HLA-DQ Gene with Bowel Transit, Barrier Function and Inflammation in Irritable Bowel Syndrome with Diarrhea
Authors: Blomqvist A, Sjöholm I, Sandström M, Söderhäll K, Pirinen M, Lernmark A, Fagerberg L, Berg L
Publication Date: 2011 Jul 21
Implementation

- Scraping: CGI scripts in Ruby
- Parsing: JSON, Javascript, jQuery
- Look and feel: HTML, CSS, & Javascript
SynBio Search
Semantic search of synthetic biology information

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# Evaluation

## Institutions (14 users)
- Boston University
- MIT
- Wellesley College

## Usability Task
- Search for a general topic
- Find 2-3 relevant parts
- Find a relevant publication
- Identify experience & author

## Data Collection
- Time to completion
- Screen recording
- Audio recording
- Observer notes

## Qualitative Methods
- Ease of use
- Post-study questionnaire
Results: User Feedback

“I liked that I could narrow down the searches based on database source.”

“Fusing search results from multiple sources is very useful. I did not have to retype my query.”

“It's intuitive to use and seems to gather all related data into one place, which is very helpful for project design purposes. I particularly like being able to filter out publications and just search for protocols/ lab notebooks.”
Future Work

• Integrated in SynBio Seminar taught by Natalie Kuldell (MIT)
• Include more databases
  – Clotho
  – SynBERC
• Increasing search engine capabilities (Boolean operators, customizable search, and more)
• Crowd-sourcing: Incorporate sophisticated feedback and experience feature
MoClo Planner

A collaborative tool for Modular Cloning
Modular Cloning

- Clones multiple DNA fragments in a single reaction
- Fusion sites – the cut and paste sites of Golden Gate cloning

Fusion Site

Promoters <-> Compatible Fusion Sites -> RBS

Promoters <-> RBS
Motivations

• Process visualization
• Resource integration
• Efficiency
• Collaboration
Level 0: Basic Modules

Level 1: Transcriptional Units

Level 2: Multigene Constructs
Implementation

• Microsoft PixelSense: Support for direct manipulation & collaboration
• Constraint–based permutation with Eugene
• Fusion site checking algorithm
• Primer design tests
• Crawl and integrating resources: Parts Registry and PubMed
Evaluation

Institutions

- Boston University iGEM
- MIT iGEM
- Wellesley College

Goal
Evaluate the usability of the program

Study Procedure
Use PixelSense in user’s lab environment

Usability Task
- Select specific parts from Parts Registry
- Build a Level 1 module
- Build a Level 2 module
- Create primers

Data Collection
- Video recording
- Audio recording
- Post-task interview
- NASA TLX questionnaire
- Engagement questionnaire

Position | #
---|---
PIs | 1
Postdocs | 1
Student Researchers | 22
Total | 24
User Study Task
Results

**Engagement**

- Focused Attention
- Involvement
- Novelty
- Endurability
- Usability
- Aesthetics

**NASA TLX**

- Mental Demand
- Frustration
- Effort
- Complexity
- Physical Demand
- Temporal Demand
- Performance
Future Work

• Support a top-down workflow

• Integrate with:
  • Clotho
  • Puppeteer
Human Practices

• SynFlo

• Outreach

• Expert Interviews
SynFlo

An interactive installation introducing synthetic biology concepts
Basic concepts

- Abstraction
- Protocol
- Safety
- Modularity
- Environmental Biotoxins
- Contamination
- Standardization
- Real world applications
What is SynFlo?

1.Selecting genetic parts
2.Inserting part into plasmid
3.Inserting plasmid into E.coli
4.Testing in virtual environment

Cambridge University’s 2009 iGEM team modified E.coli into color changing Biosensors
SynFlo
An Interactive Installation Introducing Synthetic Biology Concepts

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Implementation

- Sifteo SDK in C#
- Server-Client Protocol: Deploying modified E. coli from Cubes onto Surface
- Use of fabricated tangible objects to represent environmental toxins
Future Work

• Update to support Sifteo 2.0
• Add affordance: so Sifteo cubes reflect lab instruments
• Present:
  • Tanner 2012 conference
  • Demo at the ACM Interactive Tabletops & Surfaces 2012 conference
Interviews with Experts

• **Software Inspirations:** troubleshooting tree, intuitive database access, search engine suggestions, citation tool suggestions, potential testing groups and outreach projects

• **Data-Sharing Concerns:** collaboration styles, amount of information shared differ in industry and academia

• **Design Concerns:** patenting and brainstorming dilemma, innovation and user comfort
Summary

**Goal 1:** (SynBio Search) Simplify the research and information-gathering process

**Goal 2:** (MoClo Planner) Streamline design and specification of complex constructs

**Goal 3:** (SynFlo) Convey basic synthetic biology concepts to non-scientists
ACKNOWLEDGEMENTS

**Boston University**
Traci Haddock, Swapnil Bhatia, and the Doug Densmore lab, and the BU iGEM Team.

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**Sirtris Pharmaceuticals**
Christine Loh

**Wayne State University**
Tamara Hendrickson & her lab
Who
What
Where
When
Why
How
Questions
Answers
1. Surface sees \( \text{and} \) sends tag ID (0x02)
2. Sifteo receives ID and waits for cube to flip. Flip links cube unique ID to byte tag
3. When E.Coli is created, Sifteo app send color as a string to the surface app
What do we build on?

MoClo:
- Eugene
- SBOL (visual)
- Linking up with Puppetshow

SynBio Search:
- Parts Registry
- SBOL (visual)

SynFlo:
- e.Chromi
iPad vs PixelSense
SynBio Search

Search results (Hint: Try the special 'Search Parts' system on the main page)

There is no page titled "anderson". For more information about searching partsregistry.org, see Help. Showing below up to 20 results starting with "and".

View (next 20) (next 100) (100) (500) (500)

Page title matches
1. Ribosome Binding Site (Kasparov's Consensus) - Anderson (105,855 bytes)
   - 1. the Ribosome Binding Site by Prof. J. Christopher Anderson. (Photo: Pacifica)
   - 3. The pPAM promoter region is designed to allow for efficient expression...
   - 5. Increasing the anderson RBS parts can be found in the table below. To do...
   - 10. anderson RNA family members...

Part: BBa_I14018
Designed by Vinay Vepakam, Men Hsu, Lawrence Forman - Group: Princeton (2004-08-02)

P(Bit)
P(Bii), Medium Transcription

Usage and Biology
provider for arabinose resistance

Sequence and Features

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>negative regulator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>positive regulator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Search by exact part name e/BBa_E305114

Datasheet: BBa_I14018

Search Result for: qiagen

Go to Google Scholar

BBA K142000: SynBio Datasheet / Parts Registry
http://partsregistry.org/Part.BBa_K142000
71...C for 120 min, 4C hold. Samples were purified with Qiagen Qiaquick PCR purification kit and electroporated...

BBA K142001: SynBio Datasheet / Parts Registry
http://partsregistry.org/Part.BBa_K142001
72...C for 120 min, 4C hold. Samples were purified with Qiagen Qiaquick PCR purification kit and electroporated...

BBA K142002: SynBio Datasheet / Parts Registry

Reference

iGEM Author(s) Info

Author(s) | Vikram Vijayan, Allen Hsu, Lawrence Forman
Group | Princeton
Date | 2004-08-02
Website Link | Link
Datasheet: BBa_I14018

Description

- **Common Name**: P(Bla)
- **Type**: Regulatory
- **SBOL Image**: ![Image](image_url)
- **Experience**: 1 Registry Star
- **Availability**: DNA Available
- **Sequence**: tgaagttatatagccagagttcttgatg
- **Length**: 35 bp

Promoters for ampicillin (I14018 or “PBlac”), chloramphenicol (I14033 or “PCat”) and kanamycin (I14034 or “PKat”) resistance.

Promoter activity levels

<table>
<thead>
<tr>
<th>Promoter name</th>
<th>Activity (RPU)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBlac</td>
<td>3.46</td>
<td>0.27</td>
</tr>
<tr>
<td>PKat</td>
<td>0.80</td>
<td>0.04</td>
</tr>
<tr>
<td>PCat</td>
<td>0.10</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Promoter activity variability

<table>
<thead>
<tr>
<th>Measurement carried</th>
<th>Promoter activity variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector: Ampicillin plasmid</td>
<td>GFP: I14018 CFP: I14033</td>
</tr>
<tr>
<td>Strain: MD1020 (negative control; MD1020 DFP)</td>
<td>Cytometry: CytoFAB A405 A488 A485</td>
</tr>
<tr>
<td>Strain: MD1020 DFP</td>
<td>Cytometry: CytoFAB A405 A488 A485</td>
</tr>
<tr>
<td>Strain: MD1020 (positive control)</td>
<td>Cytometry: CytoFAB A405 A488 A485</td>
</tr>
</tbody>
</table>

BIOFAB

Updated: 3/10/10
SynBio Search

PubMed.gov
US National Library of Medicine
National Institutes of Health

Google scholar

Registry of Standard Biological Parts

Main page archive
Hierarchical Cloning

Parts → Genes → Multi-gene networks
SynFlo
Capabilities of Sifteo Cubes

- shaking
- tilting
- flipping over
- clicking
- press & holding
- sensing other cubes
- Bluetooth connectivity
SynFlo concept

- Sets of 3 cubes: plasmid, color and E. coli
- Select from 3 different colors on color cube
- Transfer color to plasmid cube from color cube by tilting
- Transfer color to E. coli cube from plasmid by flipping
- Place E. coli on Surface to deploy
- E. coli will move around on Surface environment
Preliminary user studies on 18 high school students involved a presentation on basic synthetic biology concepts, SynFlo demo, and reflection.
Final demos and project presentation encouraged Wellesley faculty and visitors to engage with our demos
SynFlo: Challenges

Working with new technology
  Lack of resources (i.e. example implementations, documentation)
  Limited memory
  Novel event handlers

Communicating between devices
  Surface -> sifteo
  Sifteo -> surface