

BrainEx DashBoard MQP Final Presentation

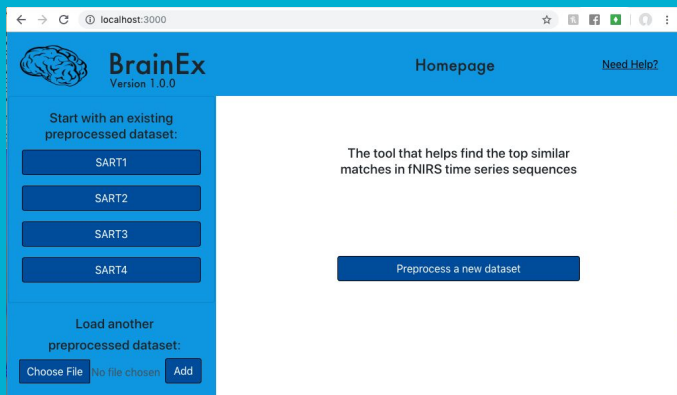


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Agenda

- Preview of Final Deliverables
- A Term Accomplishments
- B Term Accomplishments
- Final Deliverables
- Future Development
- What we learned

Preview of Final Deliverables



Implementation

Applying HCI Design Practices to the Design of the BrainEx User-Interface to facilitate fNIRS Research

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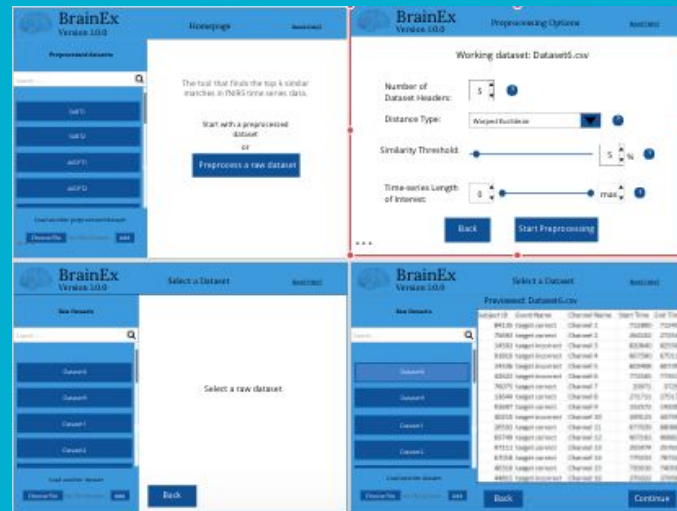
Margaret Goodwin

Yihan Lin



WPI

Final Paper



High Fidelity Mockup

A term Accomplishments

- Conducted research on fNIRS, HCI, and BCIs and became familiar with the main concepts
- Learned more about the current tools being used to preprocess and analyze fNIRS in the WPI HCI lab
- Collected user and system requirements for BrainEx by interviewing the lab members
- Started putting together a rough sketch of an initial BrainEx mockup
- Submitted the Proposal

fNIRS, HCI, and BCIs Research

Goal: Learn more about fNIRS, HCI Principles, and BCIs

Process: Research using online resources as well as meeting and discussing with WPI HCI Lab members about their day-to-day roles

Outcome: The team was able to gather more knowledge on fNIRS and BCIs and how experiments are done. They also learned more about HCI design principles such as ideation, rapid prototyping, and testing with users.

Takeaway: The team was able to get a solid understanding of the whole WPI workflow. They were also able to apply this info in their background section of the final MQP paper

Current Tools in The Lab

Goal: Find current tools that members are currently using in the WPI HCI Lab and be able to apply any of the preferences and concerns to BrainEx

Process:

- Prepare an interview question list and hold meeting times to ask users about the tools they have been using. Some questions about the tools included:
 - Why did you/your lab choose/use these particular BCI tools?
 - Have you ever felt at any point that certain functionalities you need are missing from this interface?
 - In the case of technical difficulties, how do you usually resolve them? Do you just google the problems you encounter? Search in their official documentation? Email the support team?
 - For a complete list of questions, please refer to Appendix G in the [final paper](#)

Current Tools in The Lab

Outcomes:

- Found that users mostly Aurora, RTFD, Matlab_GUI, NirsLab, and Homer 2 for data analysis and preprocessing of fNIRS data
- Many of the concerns were about lack of documentation and guidance within the application and user control as there was only a set procedure to follow

Takeaways:

- Prioritize these results in the upcoming storyboards and in the prototypes

User and System Requirements for BrainEx

Goal: Determine the requirements for the interface

Process: Interview lab target users (6) and developers (3)

Outcome:

User Need	API Function
Data Exploration	Cluster Explorer Dataset Explorer
Investigate Data Patterns	Query Best Matches for Data Sequence
Export Database	Save Database
Export Best Matches	Save Query Results

Takeaways: Personas and Models (see B Term)

B term Accomplishments

- Created User Personas to identify specific target user groups for testing BrainEx
- Created detailed models to reflect system requirements
- Iteratively designed Storyboards
- Iteratively designed Low, Mid, and High Fidelity Prototypes
- Designed Moodboards
- Tested and received feedback from users to continue to improve the prototypes
- Initial framework and functionality of BrainEx
- Final Paper

User Personas

Goal: Determine the target user groups as well as effectively communicate and sharpen design focus

User Personas

Process:

- Compile interviews conducted in A term when we learned about the different tools available in the WPI HCI lab and organize into a table with user's:
 - Name
 - Age
 - Education level
 - Titles and responsibilities
 - Goals and frustration while using the application
 - Their brief background
 - Memorable quote about the application that they mentioned

User Personas

Outcomes:

- Target users range from undergraduates to graduates, with majors mostly in CS, ECE, and BME
- 3 user persona groups: novice, intermediate, and advanced
- Undergraduates = novice, Graduates/PhD = intermediate, Developers = advanced
- Common Interview Themes of the tools: Lack of documentation and guidance, not customizable, interesting graphs and visuals

User Personas

Takeaways:

- Novice users will be the focus of the BrainEx application
- Moving forward, the team will utilize the information of target user groups to schedule user testing sessions to best achieve their design goals

Models

Goal: Model the BrainEx system in order to organize and understand the user requirements vs. technical requirements

Process:

Created 4 models:

- Conceptual Model: Objects, Relationships, Operations
- Semantic Model: Details about Functions
- Syntactic Model: States and connections
- Lexical Model: Actions relating to states

Models

Outcome:

Conceptual

<u>Objects</u>	<u>Relationships</u>	<u>Operations</u>
<ul style="list-style-type: none">• SparkContext• Dataset (Genex database)• Query object• Query results	<ul style="list-style-type: none">• The other objects reside within the SparkContext• Query results are subsets of dataset• Query result is generated from query object	<ul style="list-style-type: none">• Load database• Build database (this does the clustering) w/ build specifications (length of interest, type of distance, similarity threshold)• Save database• Generate query• Query database• Plot query results• Explore clusters• Explore dataset

Models

Outcome:

Semantic

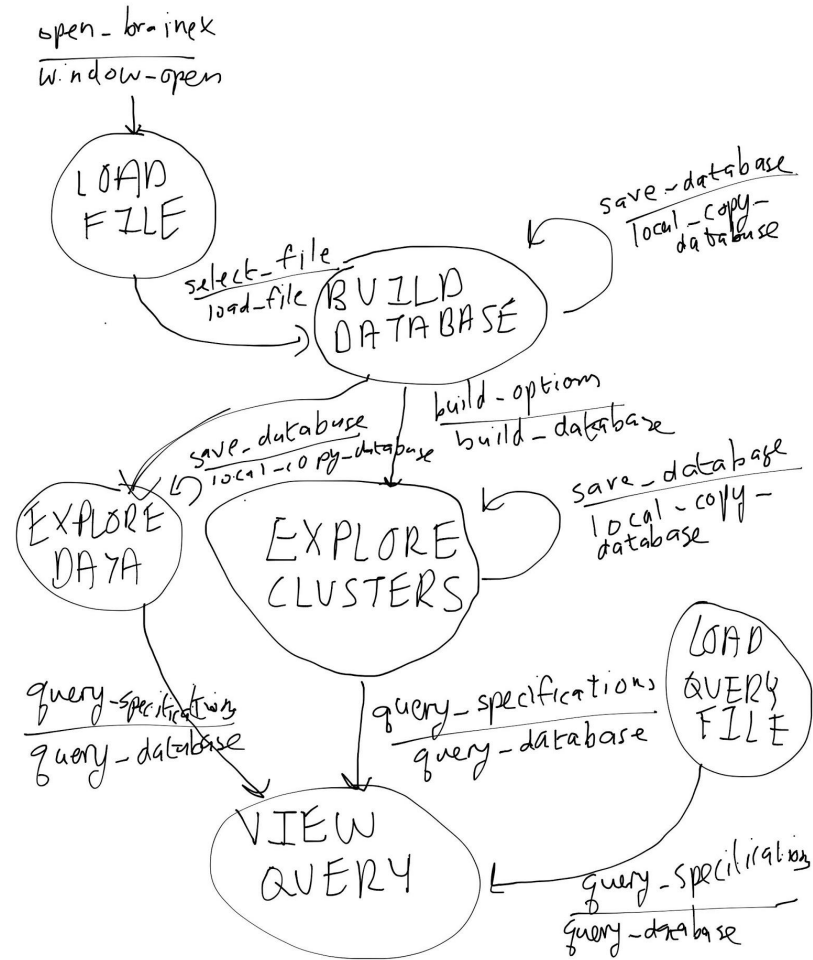
(one function)

Function	Query database
Parameters (implicit and explicit)	(built) Database/self, query object, number of best matches, boolean of whether to exclude representative sequence, overlap threshold; Spark Context must exist
Description	Generates an object that holds results for best matches based on a given query object
Feedback	Display query results if query can be computed, give error message if not
Error Conditions	<ul style="list-style-type: none">- Give error message if query object is invalid- Limit user input to ensure best matches is a positive whole number- Limit user input to ensure overlap threshold is a number between 0 and 1

Models

Outcome:

Syntactic



Models

Outcome:

Lexical

Action	Definition
Window_Open	Click BrainEx icon
Load_File	Browse to desired database or CSV file -> click load
Local_Copy_Database	Click save database
Build_Database	Enter similarity threshold on slider, enter length of interest in 2 textboxes, select distance type from dropdown menu -> click build
Query_Database	Navigate to query tab -> Enter number of best matches in textbox, check box of whether to exclude representative, Enter overlap threshold on slider -> click query

Models

Takeaways:

- While there aren't many types of objects to deal with, there may be many instances of objects that hold much data, so we need to pay careful attention to their handling
- Planning for error handling needs to happen early!
- There are relatively few states and actions involved, so there will probably be fewer screens than we expected

Problem

The WPI Interaction Lab has created a robust tool called BrainEx to find best matches for time series in fNIRS BCI data. Researchers desire this capability because it helps discover patterns in their data. However, BrainEx is currently in need of a user-friendly graphic interface.

fNIRS BCI



A student uses an fNIRS BCI cap while performing a task. Researchers can then use the collected data on brain hemoglobin levels to gauge the student's concentration.

Proposed Solution

The team proposes the development of a user interface built upon the BrainEx API following the user-centered design process to ensure utility and usability.

Understanding system requirements

The team interviewed 6 target users in the lab and 3 developers. They then mapped each user need to the API function that would fulfill it:

User Need	API Function
Data Exploration	Cluster Explorer Dataset Explorer
Investigate Data Patterns	Query Best Matches for Data Sequence
Export Database	Save Database
Export Best Matches	Save Query Results

BrainEx System Model

Objects	Relationships	Operations
<ul style="list-style-type: none"> •Dataset (BrainEx database) •Query object •Query results •Result plot 	<ul style="list-style-type: none"> •The other objects reside within the dataset •Query results are both subsets of dataset •Query result is generated from query object •Result plot is a visual representation of the query results 	<ul style="list-style-type: none"> •Load database •Build database (this does the clustering) w build specifications (length of interest, type of distance, similarity threshold) •Save database •Generate query •Query database •Plot query results •Explore clusters

One of four models created by the team to examine the BrainEx system

Iterative Prototyping

Started with storyboard to focus on flow of functions



Feedback

Created low-fidelity interactive prototype to test screen layout

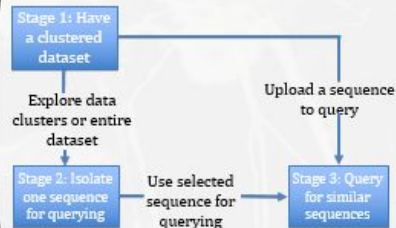


Feedback

Designed mid-fidelity interactive prototype to refine flow and layout



Interface Flow



Gathered Feedback

Positive	Negative
Visualization of dataset	Unclear control flow
Visualization of cluster	Jargon overuse
Display of query results	Unclear menu structure
Data filtering	Unlabeled buttons
Learnability	Inconsistent naming

Highlights from feedback on all three levels of prototypes

Further Development

- Complete high-fidelity prototype
- Get user feedback on high-fidelity prototype
- Implement prototype using Agile methodology

Acknowledgements

Thank you to Professors Erin Solovey and Rodica Neamtu for their work as advisors. Thank you also to the developers of BrainEx and students in Professor Solovey's lab for their insight into our project.

Sources

[https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4111111/](#)
[https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4111111/](#)

Storyboards

Goal: Ensure that the team's understanding of and plan for BrainEx meets the user needs and accurately reflects the system behind it

Process:

- Created a storyboard for each individual feature of the envisioned system (e.g. uploading a file, zooming in on a graph, etc.)
- Presented multiple versions to allow users to provide useful feedback on different ways of handling it.

Storyboards

Outcomes:

- The users expressed confusion in the representation of the data attributes in the storyboard and how they would access data in the application.
- Flaws with the team's testing methods, such as not presenting the goal of the application before beginning to ask questions.

Storyboards

Takeaways:

- The team made sure to refine their storyboards in the next iteration to solve some of the concerns
- The issues were prioritized first and taken into account when designing the low fi prototype
- The team adjusted their user testing methods to start of with a preamble explaining what the team is doing and what BrainEx is, which significantly helped users

for Mockup: focus on the parts we don't know how to present

query \rightarrow ^{CU} cluster explore

Genex.

#1

Genex

- Previous built. False
- New dataset true

Upload.

BQ

length	50	▼	Rep: 1
TS	sequence	0	0.000000
1	~~~~~	0	0.02

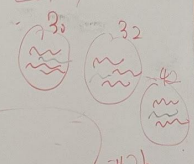
AQ

50000

Genex - Query #3

Vis1	Vis2	Vis3
------	------	------

#3



Genex #2a

⇒ # of iterations: [10] [100]

length of interval: [10] [100]

SIM thrush: placeholder text: between 0 and 1

dist type:

Back last time

#2b

Stats

✓ 100%

cancel build

X Verbose

50
51
52

Parameters in Query

Query:

Best k:

Unique ID:

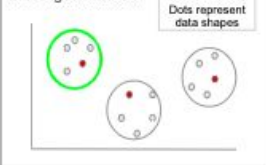
Overlap:

Sketch of storyboards

Storyboards

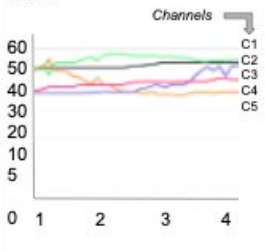
Display Cluster Explorer

Kia is not sure what exactly she wants to query based on the selected data. She can view the following regions to get an idea of how similar the data are in particular clusters, grouped by the length of the time series data within the cluster, and then select a cluster to investigate further.

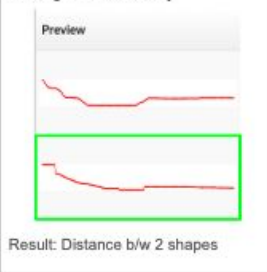


Kia chooses to view the cluster selected in green

Kia can view a cluster that looks very unique and needs more attention. She can view a graph of the different points in the selected cluster.



Kia can also view the list of shapes of the graphs in a table which she can then pick and choose to investigate more closely.



Kia chooses to investigate the data shape selected in green

Choosing a cluster from the data viewer - p1

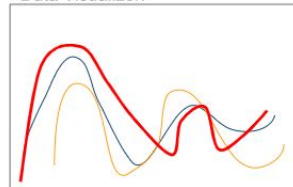
Kyra selects cluster 5 in the data viewer.

Data Viewer:

	ID	Length	size (# of sequences)	shape
■	1	50	100	(thumbnail)
■	2	50	85	(thumbnail)
■	3	51	117	(thumbnail)
■	4	51	44	(thumbnail)
■	5	51	200	(thumbnail)
■	6	52	15	(thumbnail)
■	7	53	64	(thumbnail)

The cluster is highlighted in the data visualizer. She decides she wants to view the contents of this cluster and selects "view cluster" on the screen.

Data Visualizer:



View Cluster

10

Version 1



Version 3

Low Fidelity Prototype - Utility Refinement

Goal: Create an initial prototype that focuses on the dataset explorer and query result page. Have the current prototype meet user needs and accurately reflect the backend capability. Have an easily understandable structure within the prototype.

Process:

- Brainstorm ideas for the prototype in team meeting using our HCI knowledge to create designs and building on top of backend capabilities
- Design on Balsamiq
- Confirm with Leo the feasibility of the features for implementation purposes
- Team members perform heuristic evaluations individually
- Conduct User Testing
- Wrote UARs to consolidate the user result information

Low Fidelity Prototype - Utility Refinement

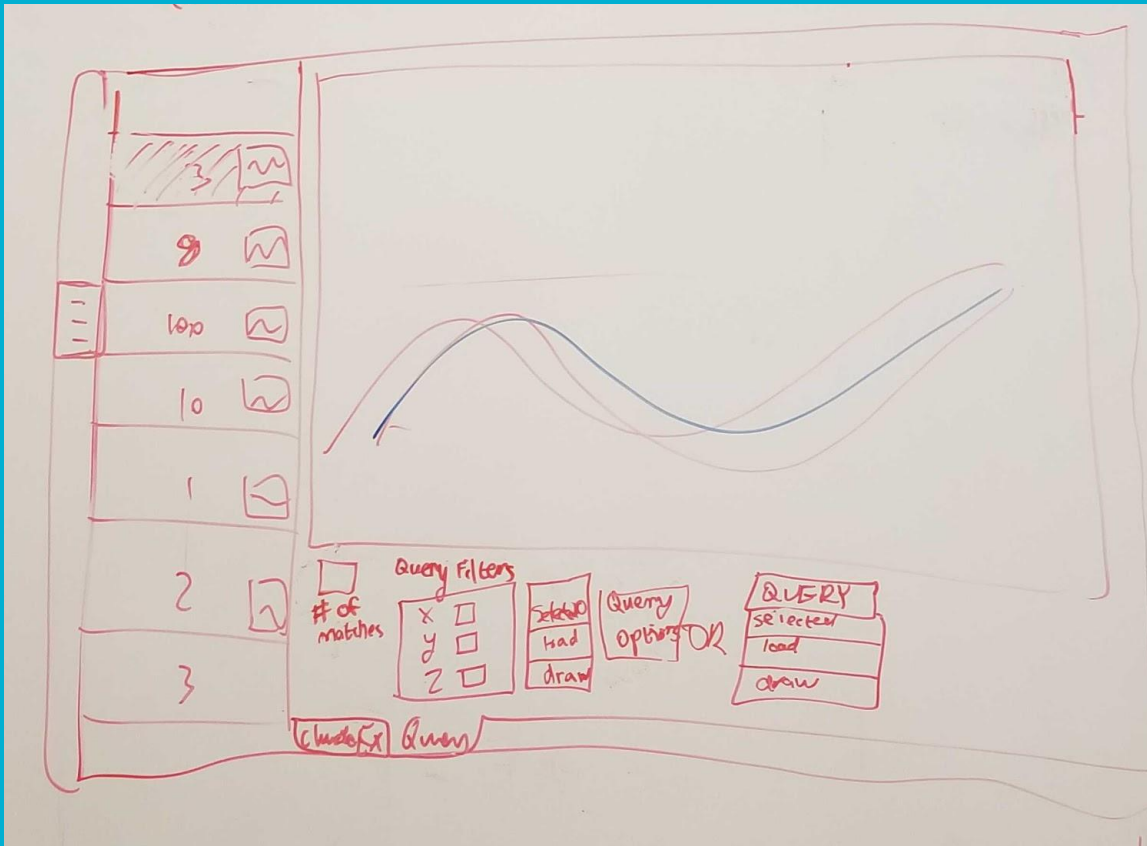
Result overview:

- A low-fi prototype that provides a clear, more simplistic structure than Genex.
- Demonstrates a control flow and interactive capabilities to simulate the real application.
- Team members gave reviews to focus on error prevention and documentation.
- Users mentioned control flow and clarity needs improvement.

Low Fidelity Prototype - Utility Refinement

Takeaways:

- Shift our perspective from the developer's point of view to the user's point of view while taking into account the capability of the backend.
- Use site maps to help us solidify the overarching structure of the design.
- Current version of design excels at giving user control and freedom. However, this might not be as desirable to novice users.
- The most confusing aspect was the navigation from screen to screen and something we did well are the data visualizations and the providing useful filters



Sketch of query finder page low-fidelity BrainEx prototype

BrainEx Homepage Dataset Explorer Cluster Explorer Query Finder

Current Selection

Filter

Channel

- Channel1
- Channel2
- Channel3
- Channel4
- Channel5

SubjectID

Labels

Statistics

Data Visualizer

Data Viewer

SubjectID	Event Name	Channel Name	Start Time	End Time
101 HART	target correct	Channel-1 HBO	300	9000
93 SART	target incorrect	Channel-4 VBO	789	45756
34 TART	target no response	Channel 18 JVO	210	45900

Save file

Query Selected Sequence

Query finder page from low-fidelity prototype

Mid Fidelity Prototype - Usability Refinement

Goal: Make sure control flow is as intuitive as possible before moving onto high-fi design where we can include more design elements. Allow users understand/navigate through the system without much external guidance.

Process:

- Started with 2 different versions to test the user response in regard to the control flow
- Made major changes to combine the strengths in both versions
- Fixed small details based on heuristic evaluation results

Mid Fidelity Prototype - Usability Refinement

Outcomes:

- This time we made sure to fix anything either 1) important or 2) can be done quickly; to address any issues ASAP before another user testing.
- According to the team, areas that need focus are error prevention and flexibility (shortcuts).
- A total of 5 subjects that tested the application overall gave positive feedback. There were not many concerns with this prototype other than adjusting control flow and users said this version was better than the low fi

Mid Fidelity Prototype - Usability Refinement

Takeaways:

- Continue being adaptable. Apply changes quickly unless the issue needs a serious discussion among the group.
- Moving forward, we will have to make tradeoffs to address issues for specific users. Prioritization will be necessary.
- User tasks should be worded more clear and concise, which will be addressed in the high fidelity prototype
- Start moving our mockup to Invision to gradually shift our focus to usability by including more visual elements that are more difficult to achieve with Balsamiq.

BrainEx

Current Query selection

Stat

Sequence avg
length: _____
total data
points: _____

Filter

- Subject ▾
- Channel ▾
- Label ▾

Visualization

Class 1 x

Class 2 ■

Label 1 *

Label 2 - -

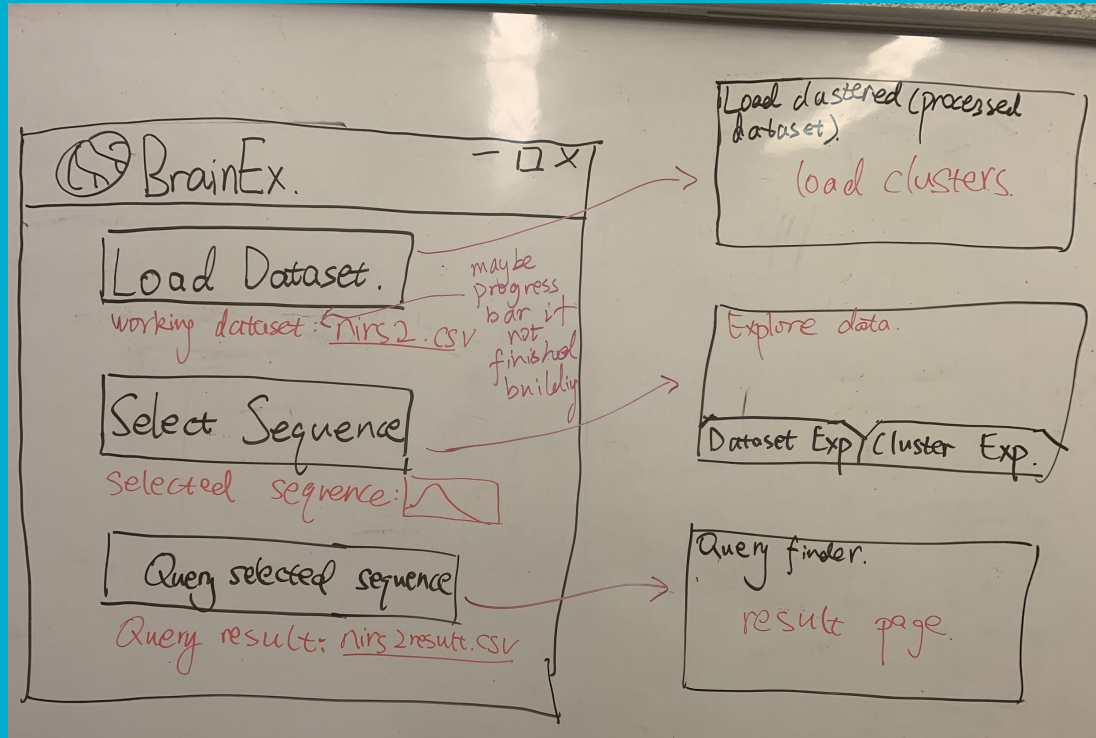
+

Table

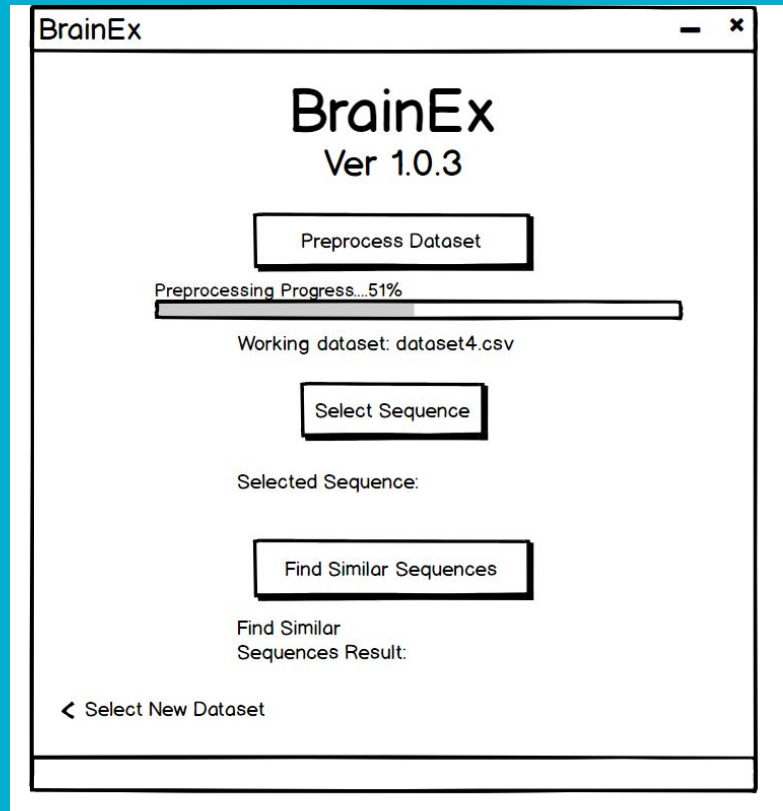
Use selection Save CSV

Data Explorer | Cluster Explorer | Query Result

Sketch of mid-fidelity BrainEx prototype Ver.1



Sketch of mid-fidelity BrainEx prototype Ver.2



Mid-fidelity BrainEx prototype Ver.2

Moodboards

Goal: Articulate the correct tone for the users' demographic and map out the team's potential choices of font, color, and styles that the team can use when creating the final prototype.

Process:

- Used Adobe to find appealing color schemes, fonts, and pictures to emulate the style of BrainEx that the team envisioned
- Collected feedback from five users in total and asked their preference on the two following moodboards.

Moodboards

Outcomes:

- 4 out of 5 users preferred Version 1 - the blue color scheme
- The team decided to adopt a blue color scheme and font choices of Open Sans (for texts) and Lora (for headers).

Takeaways:

- It was interesting to see during the process of designing the moodboards how different color choices and fonts can instill essentially different themes or “moods” throughout the application

Final Deliverables

- High Fidelity User Mockup
- Implementation of initial framework and functionality of BrainEx
- Final Paper

High Fidelity Prototype - UX Refinement

Goal: Incorporate more details and interactions into the design and center the design around previously defined user tasks to gather the most useful feedback. Have a fully designed and interactive prototype.

Process:

- Quickly tested multiple tools including FluidUI, Proto, and Adobe XD to determine the most effective tool to create the screen designs
- Implemented the mockup on Adobe XD, which was later transferred to Invision to enable the navigation and interactivity
- Tested the prototype with 3 users in the HCI Lab

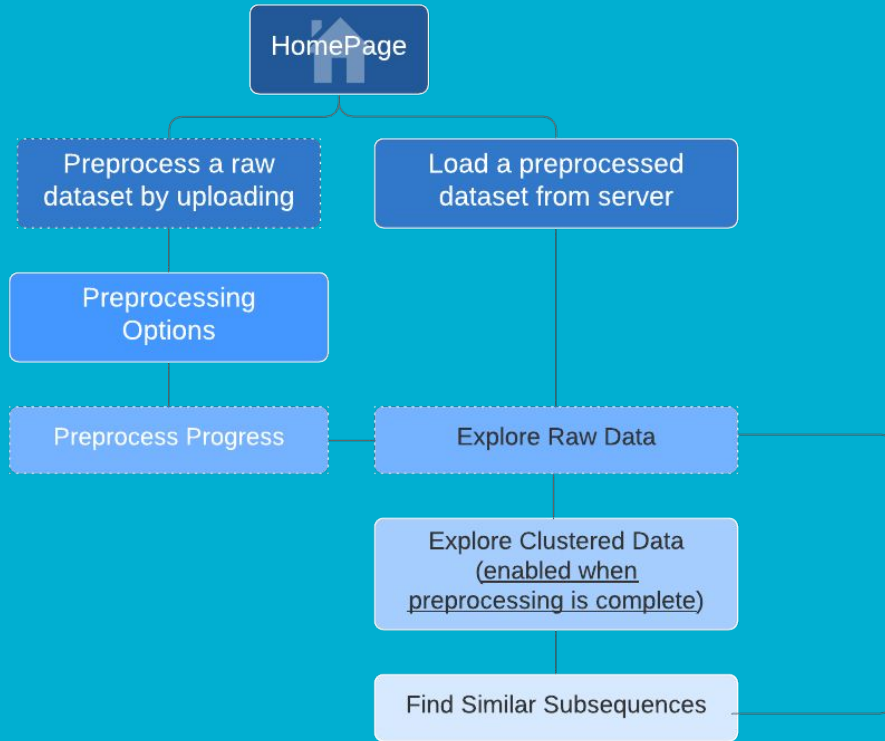
High Fidelity Prototype - UX Refinement

Outcomes:

- A very detail-oriented prototype design.
- Addresses previous issues such as inconsistent and confusing label names.
- Most of the user feedback were not any major concerns in the application, but rather about aesthetics, designs, and placement of content on the page.

Takeaways:

- At this point, some decisions that we try to make do not have “correct” answers as it is largely based on user opinions and preferences.
- There will have to be tradeoffs and we will need to weigh the user feedback in order to make the final design choice.



Site map for high-fidelity prototype

Demo!

Implementation

Goal: Set up an initial framework and functionality of BrainEx so that the team can immediately pick up implementation in C term

Process:

- Consult the backend developers on how to run through the BrainEx command line
- Look at tutorials and online resources about creating a React application as well as uploading files to the server
- Show the progress to the team and advisors for feedback
- Improve the previous version based on user feedback

Demo!

Implementation (Part 2)

Outcome/Accomplishments:

Initial Framework

- Configuring React, Bootstrap, Express/Axios Server, Backend in one frontend project
- Developing all the page components and templates of each screen in the high fidelity prototype
- Adding Navigation/Routers/Buttons to all the page components

Design

- Creating the frontend of the homepage screen
- Creating most of the frontend for the CSV Data Viewer screen

Implementation (Part 3)

Outcome/Accomplishments:

Documentation

- Added documentation to the frontend and server code
- [Hosted on Github](#) to enable easier version control
- Wrote a [tutorial](#) for those who would like to further work on the program

Server

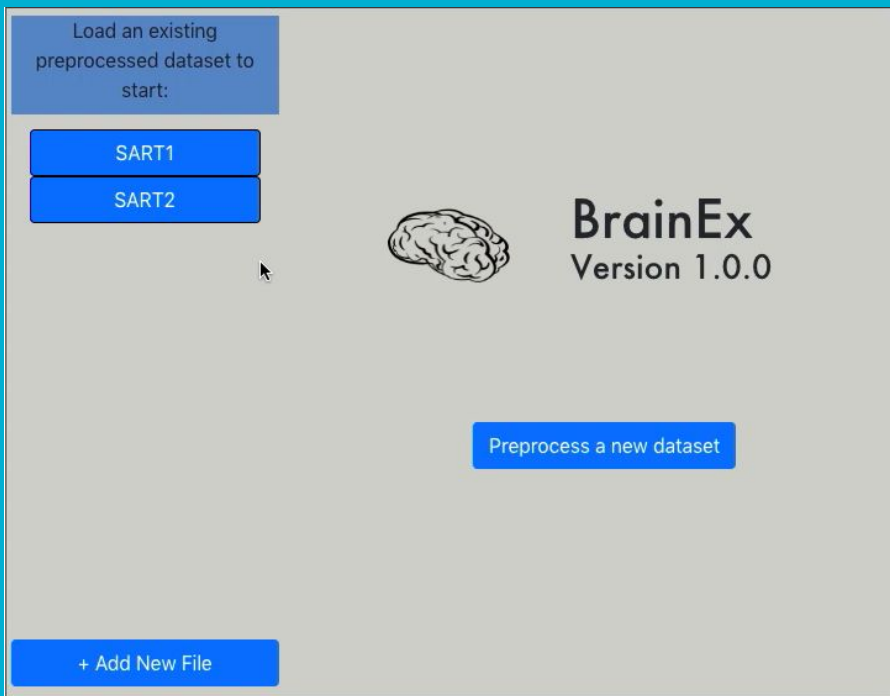
- Wrote and tested the Express Server to acquire and process client side info. For now, the info includes the files uploaded to the UI by the user
- Adding the BrainEx backend created by the developers to the frontend project directory. Ran through the command line and the gxdb object has been created.
- Completed the functionality to allow the user to upload files to the homepage screen and server. Multiple csv files can be added on the UI, which then get added into a data folder in the project directory
- Error Checking: The only files that get uploaded are “.csv” files. All other files, such as image files, will not be added to both the UI and server

Implementation (Part 4)

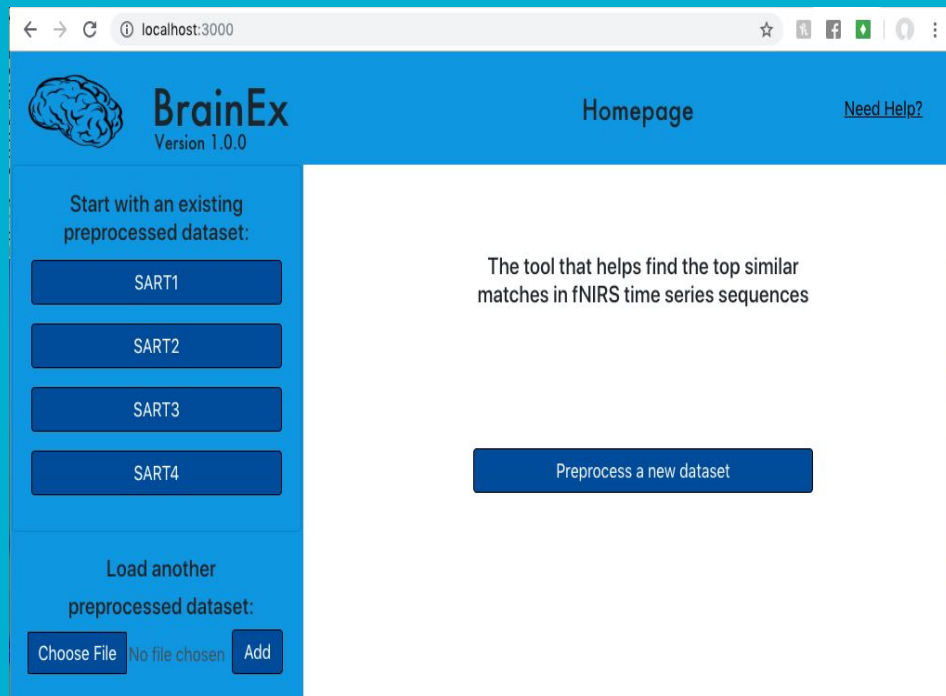
Takeaways:

- Quickly being able to learn and integrate different technologies
- Implement aesthetically appealing designs in the frontend
- Know who to go to for help and be able to solve errors in the app
- Presenting and communicating the work being done
- Collecting, prioritizing, and applying feedback to improve BrainEx
 - Some feedback in the first implementation included getting rid of the background interface container in gray
 - Improving the homepage UI to look more professional
 - Making sure buttons and text are aligned
 - Determine a better color scheme

Implementation (Part 5)



Before



After

Future Development (Prototypes)

Items not addressed in the mockups:

- For a previously preprocessed dataset, navigate straight to preprocessing options screen and don't need to show the csv file in CSV Data viewer
- Make BrainEx more consistent with other tools in the lab, such as the Matlab Gui, in that the user inputs and selections can be on the right side of the screen instead of the left
- For the help button, don't use a a long readme document and instead have tooltips/question mark buttons with descriptions and some examples of the feature that is being elaborated if the user wants it
- For more items that were tabled, please refer to [this document](#)

Future Development (Implementation)

Items to be addressed during implementation (C term):

Homepage

- Dynamically adding a button with the file contents every time the user uploads a csv file and clicks on “Add”
 - Error Checking: User should not be able to add the same file again and check if the files have already been preprocessed
- Add a pop up window/content for the “Need Help” button

Future Development (Implementation)

Items to be addressed during implementation (C term):

CSV Viewer

- Determine how to add the “choose file” functionality on two separate components in react (home screen and CSV Viewer) -> specify in the express server that the files uploaded on the two separate pages go into different folders in the project
- Preview the CSV file when, for example, the user clicks on the dataset1 button

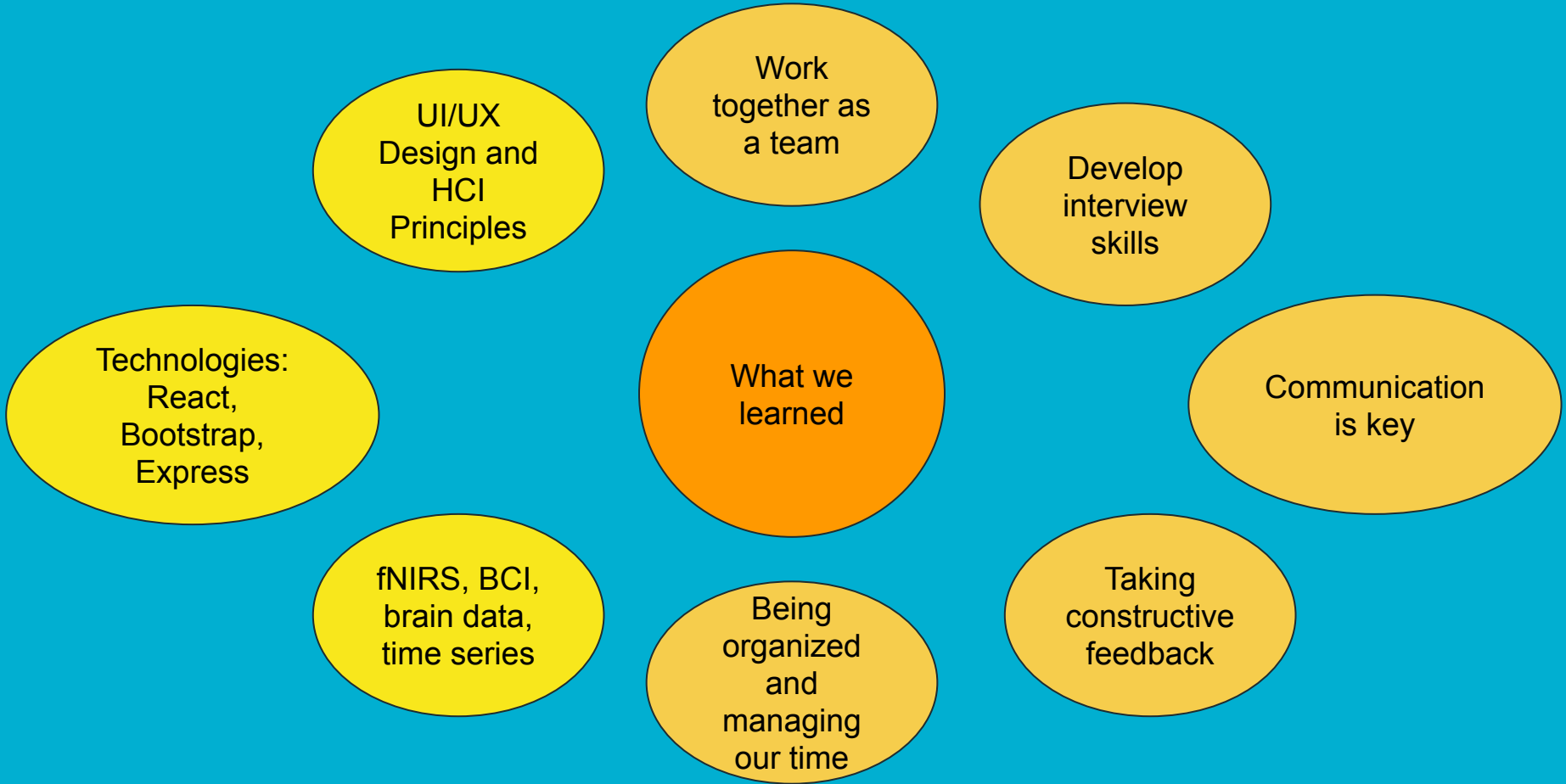
Future Development (Implementation Pt 2)

Items to be addressed during implementation (C term):

Preprocessing Options

- Clean up the user inputs to make sure the labels and actual user inputs are on the same line
- Add pop ups/content to the question mark buttons next to each user input
- Have a double range bar for the length of interest option
- Add feature number as a user input parameter
- Retrieve the user inputs from the client side using Javascript and then pass them to the backend to proceed with preprocessing

The rest of the screens, such as the progress bar to show the status of clustering the data, explorer screens for viewing raw data and clusters, and the find similar sequences screen need to be implemented from scratch.



UI/UX
Design and
HCI
Principles

Work
together as
a team

Develop
interview
skills

Communication
is key

Taking
constructive
feedback

Being
organized
and
managing
our time

Technologies:
React,
Bootstrap,
Express

fNIRS, BCI,
brain data,
time series

What we
learned