Neuropathy Simulation : Natural Language Processing

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Traumatic Brain Injury: Defining the Problem

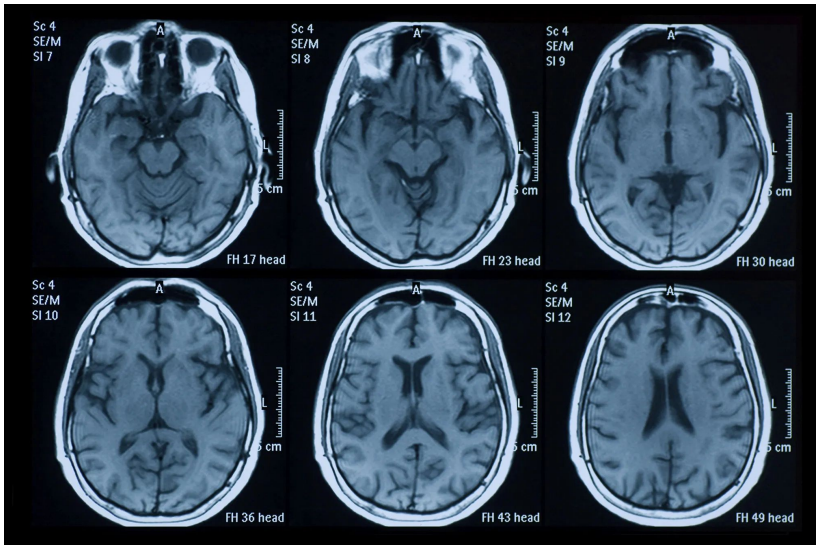
- Traumatic Brain Injury (TBI) is an alteration in brain function caused by an external force

- Diagnosed with neurological examinations in conjunction with radiology

- Majority of graduating medical students uncomfortable performing neurological examinations due to:
  - Lack of clinical exposure
  - Lack of practice [1]

Traumatic Brain Injury: Defining the Problem

- Over-reliance on radiology
  - No significant correlation between CT / MRI abnormalities and TBI severity (2,3,4)
- TBI misdiagnostic rate
  - Up to 56% for mild TBI (5)
  - Up to 51% for severe TBI (6)



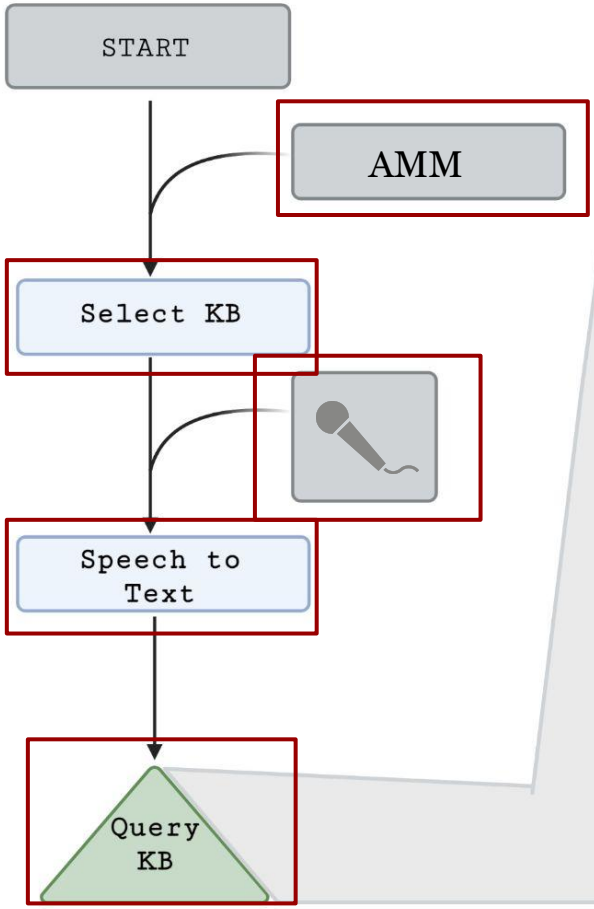
Project Goal / Deliverables

Goal : *Increase physician competence performing neurological examinations by establishing interactive natural language processing capabilities specific to neuropathies in a medical training manikin by UW CREST (Advanced Modular Manikin).*

Deliverables :

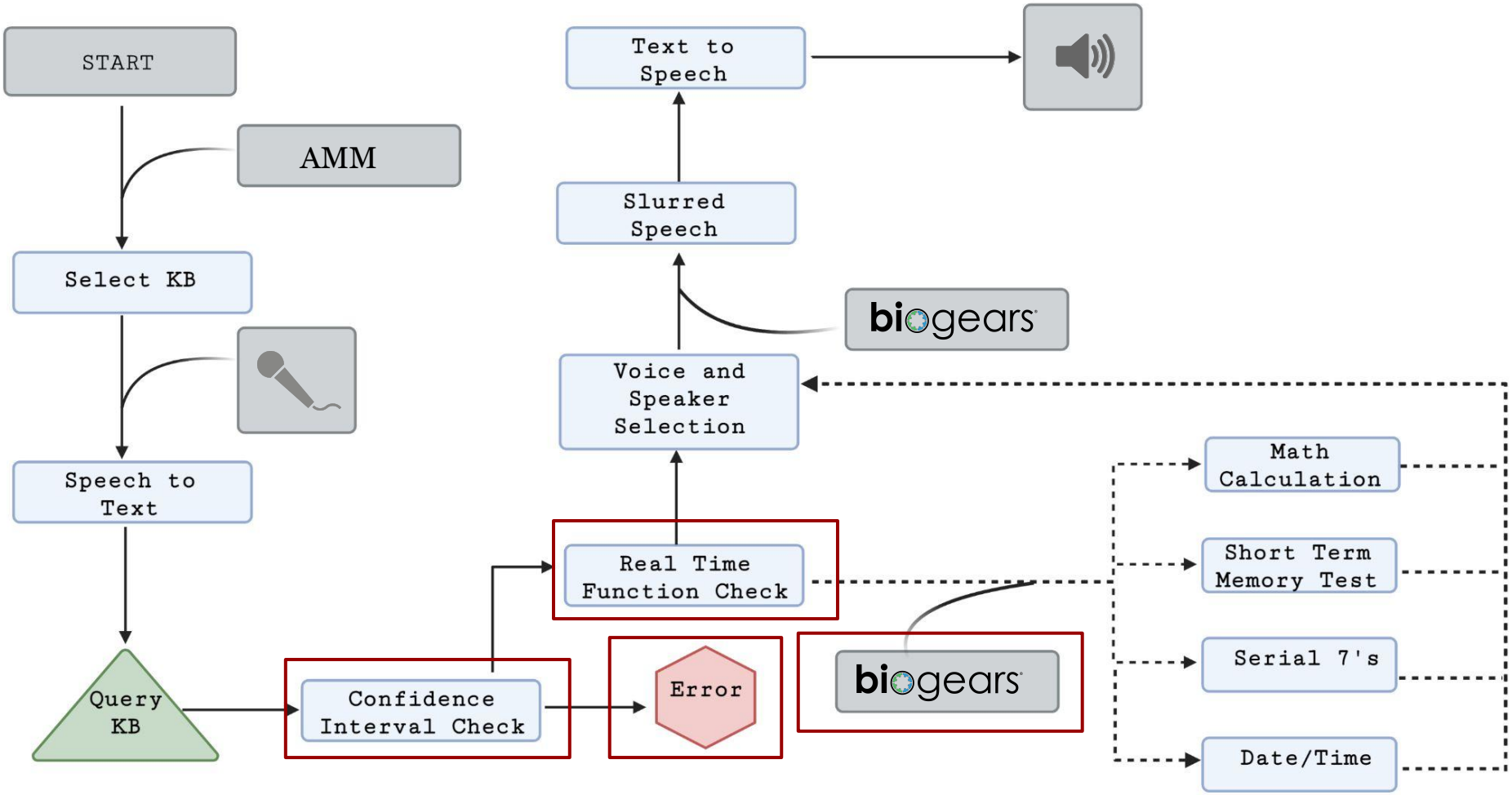
- Natural Language Processing Program
- Neuropathy-specific simulation capabilities

Natural Language Processing Program

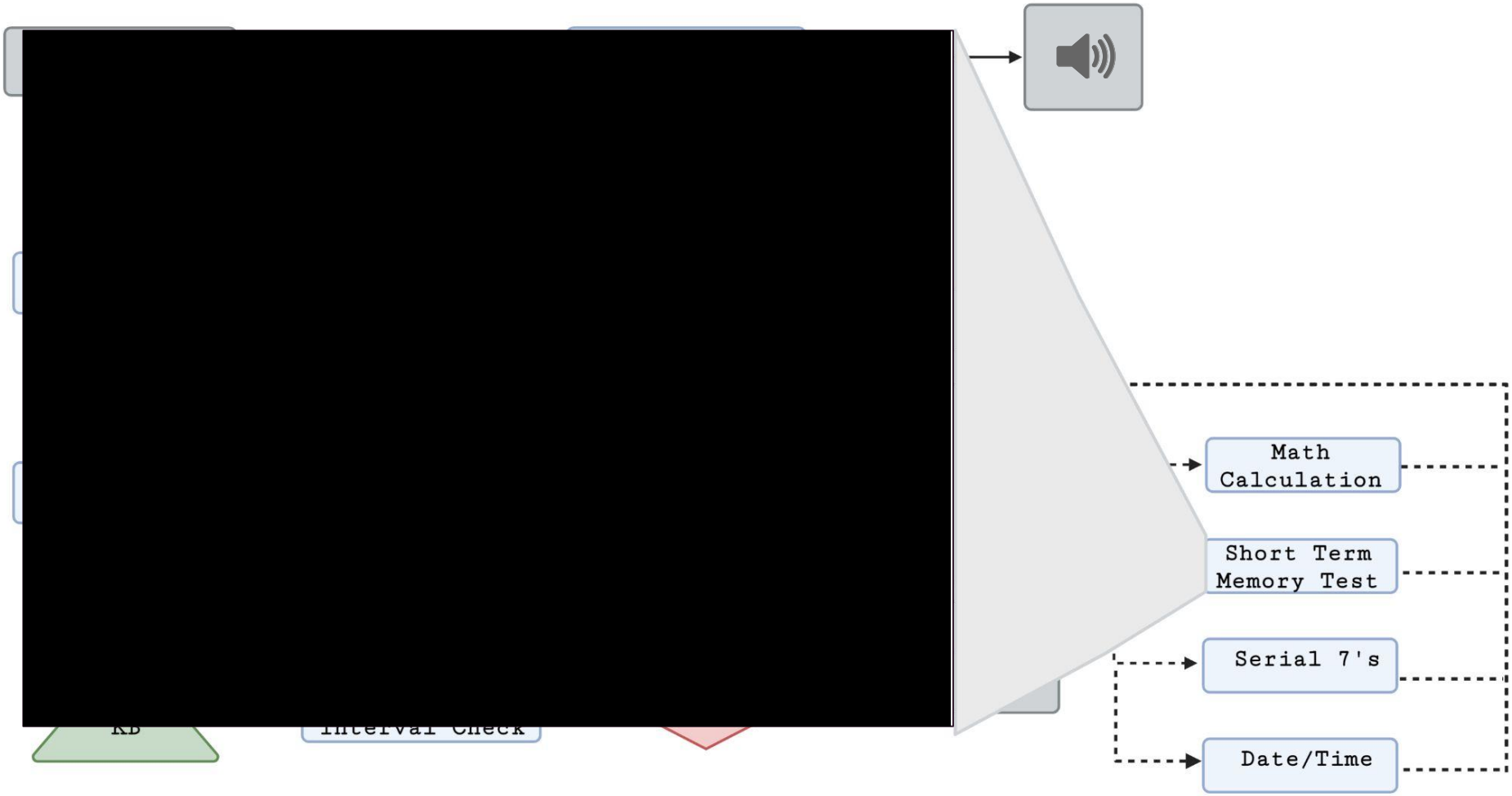


Question	Answer
When did your symptoms begin?	…….
Do you know where you are right now?	…….
How are you feeling?	…….
Please remember the following words:	……

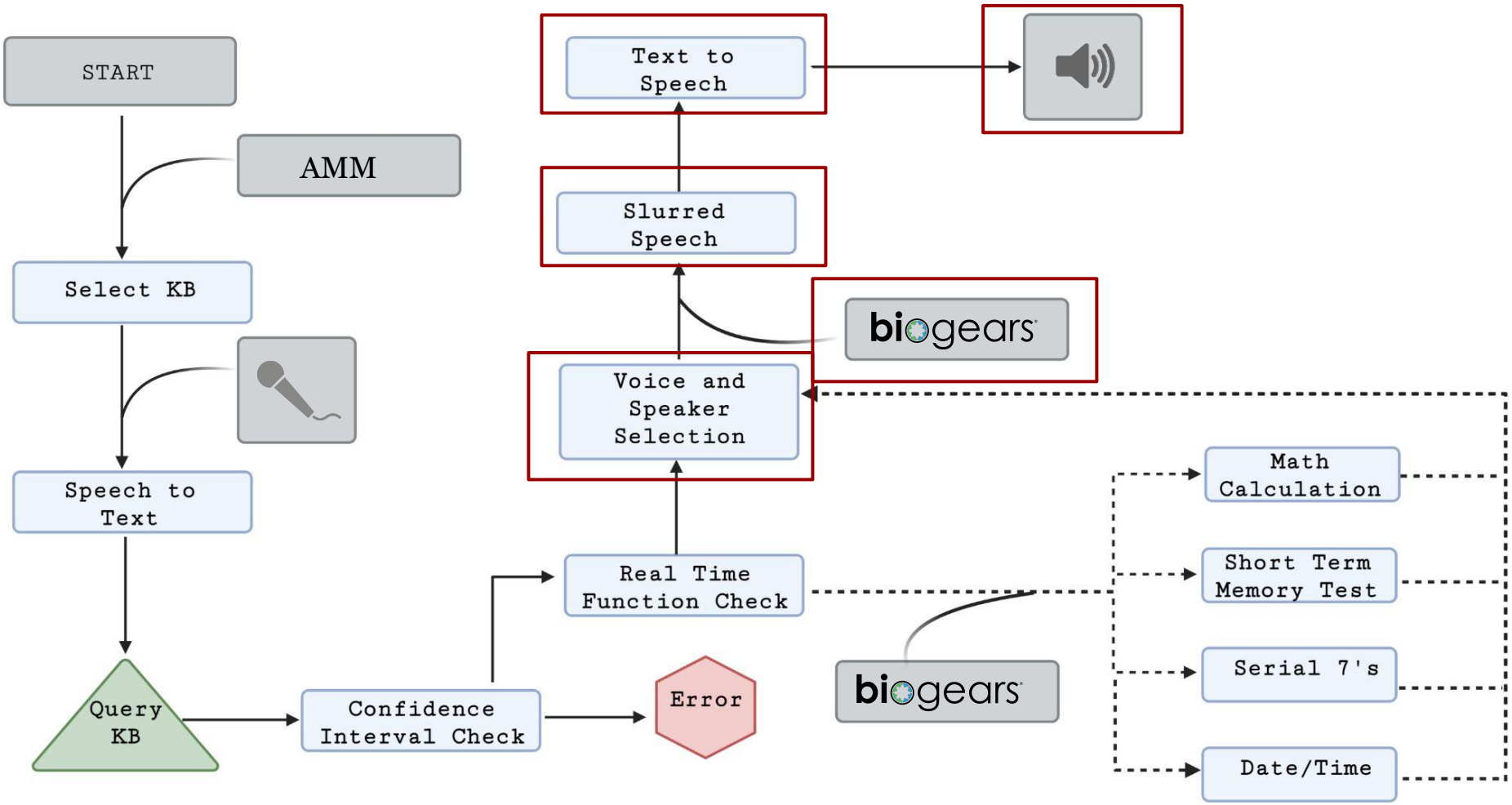
Natural Language Processing Program



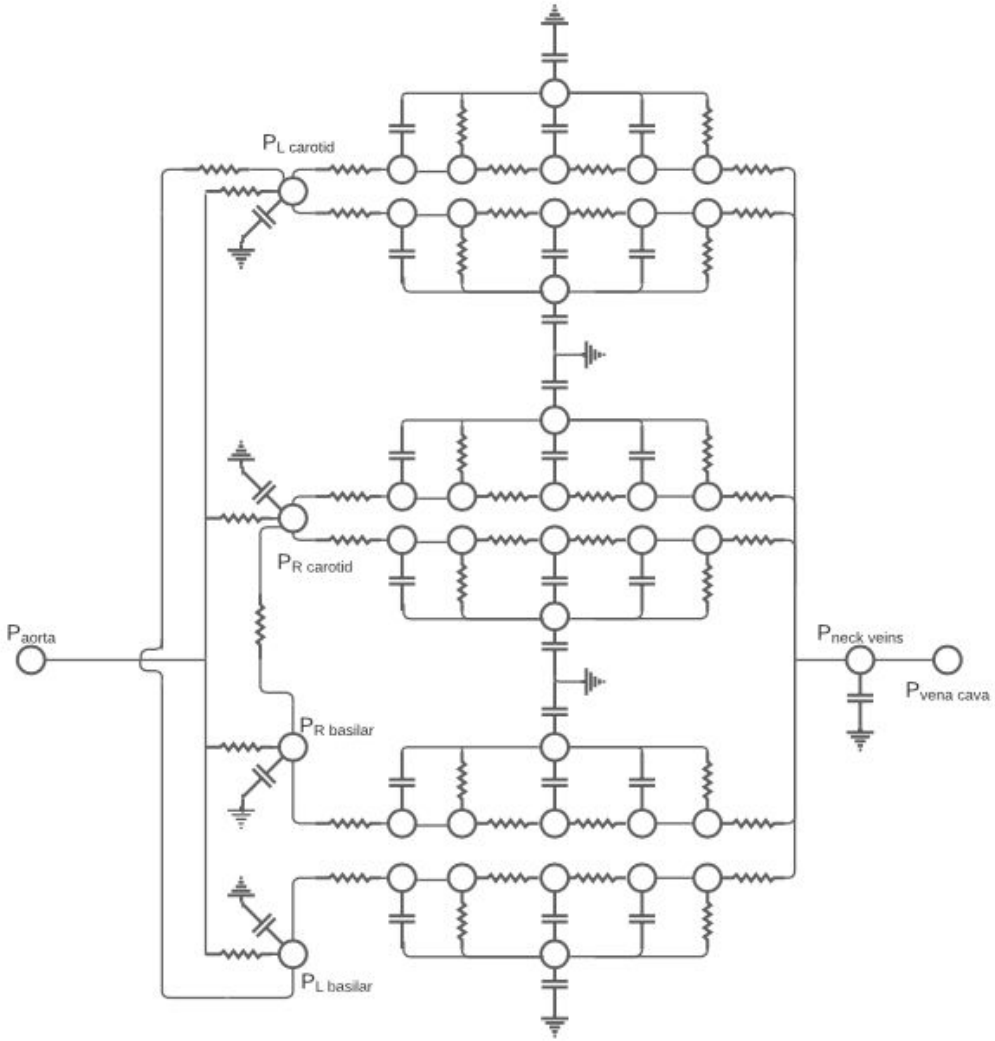
Natural Language Processing Program



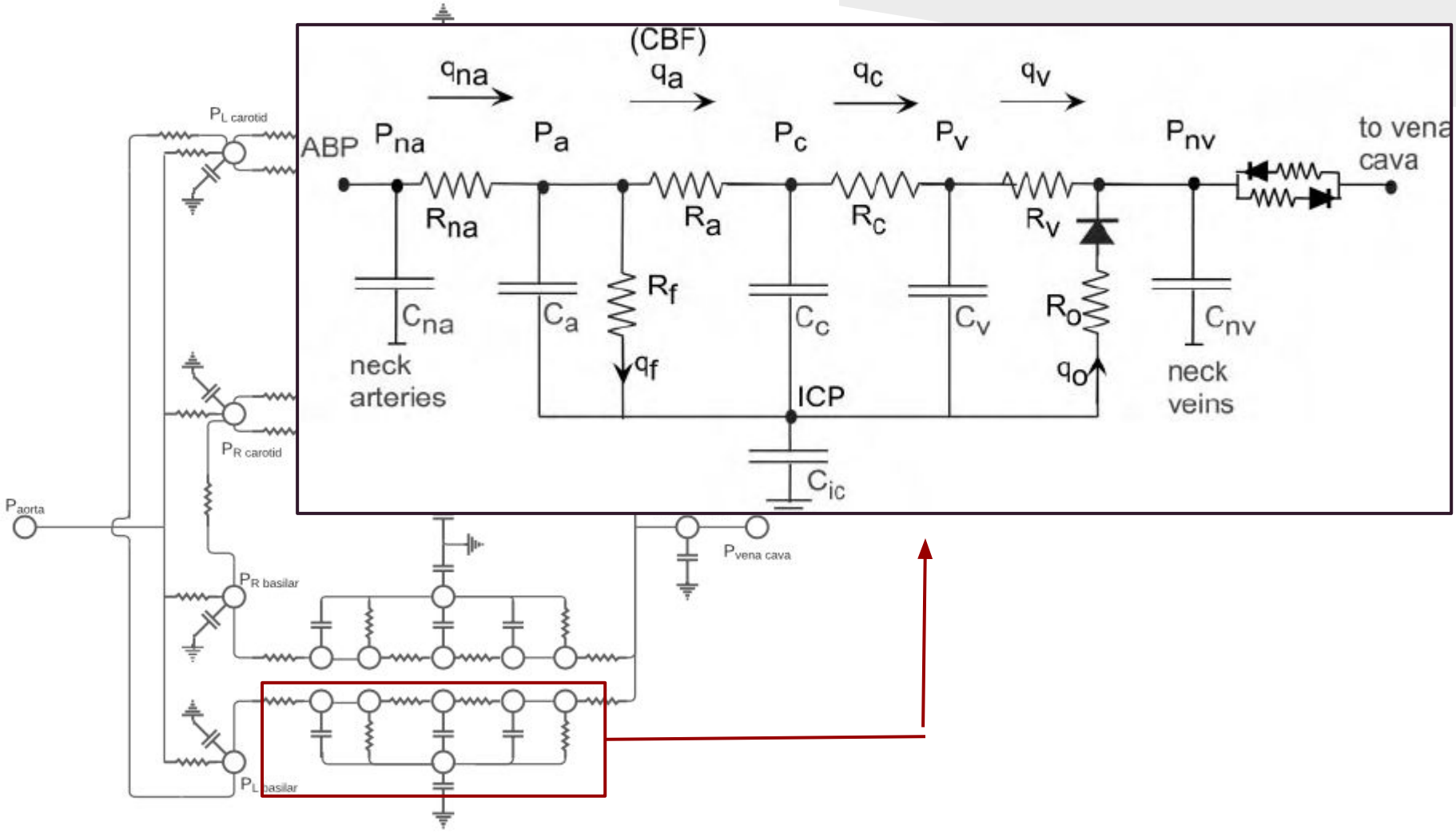
Natural Language Processing Program



Advanced Cerebral Circuit



Advanced Cerebral Circuit



Usability Design Elements

Medical Personnel, Students

Programmers, Software Developers, Engineers

Usability Design Elements

- Basic console interface for adding, deleting, or altering knowledge bases

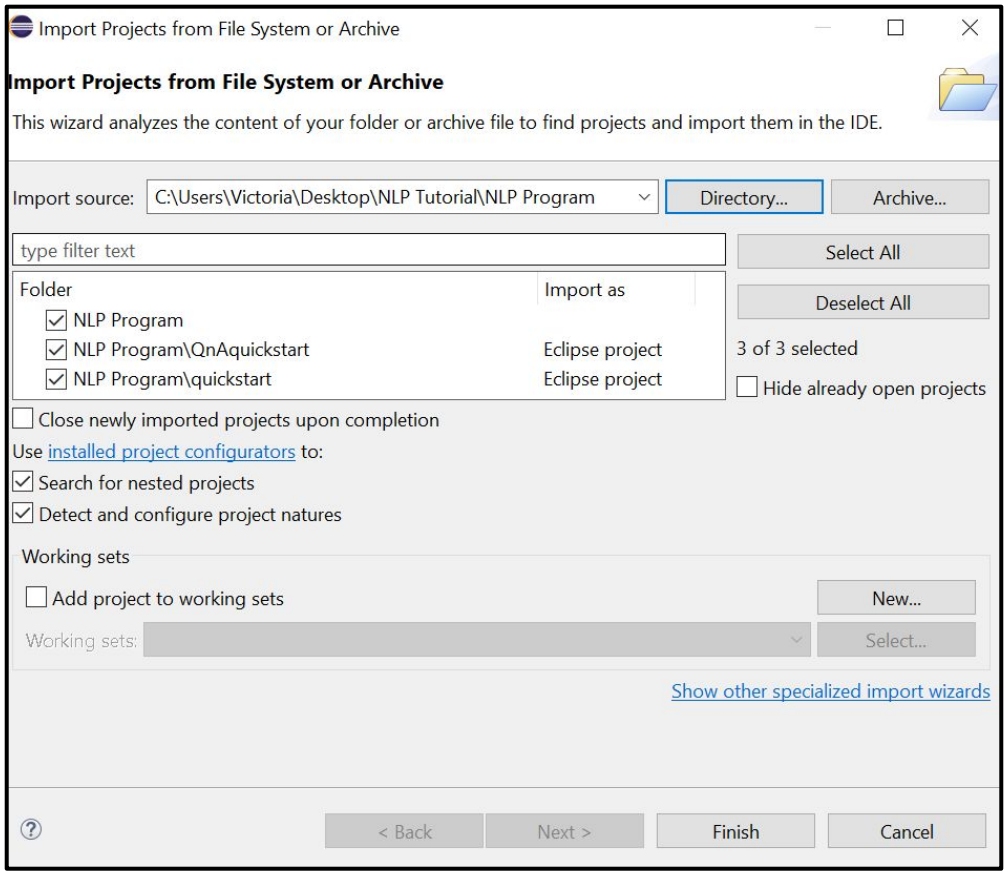
```
Welcome to the Knowledge Base Manager. The following knowledge bases exist:

Name:                                          Knowledge Base ID String:
Right Parietal Stroke Patient                  4b65e5d7-f218-4c32-88a7-e225d89abcca
Healthy Patient                                7576efa7-985b-40b0-8de7-d694e8cf8409
Practice Healthy Patient                       7be066cc-2c48-42c2-b6c5-e66c6103e2d1
Sepsis Patient                                 94a5387f-f2a5-4a96-8f7b-9af8034761bc
Left Parietal Stroke Patient                   a4f57396-e1a5-4704-8c44-6dab18949d44
Occipital Stroke Patient                       e7dc1d06-f0c8-4706-aada-d8ae59ec3136


Enter the number of the operation you would like to perform, or 0 to quit:
1. Create .xlsx file summary of an existing knowledge base.
2. Update an existing knowledge base.
3. Create new knowledge base.
4. Delete a knowledge base.
```

Usability Design Elements

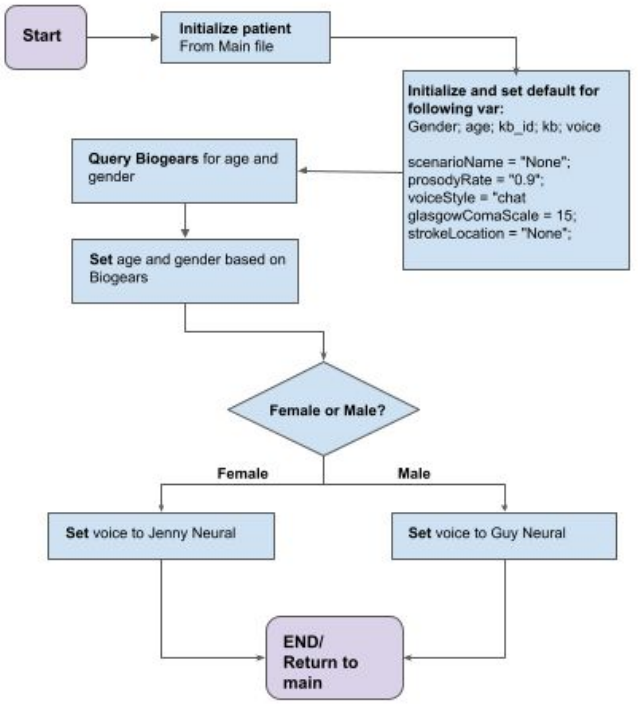
- Visual graphics instructional file as optional download



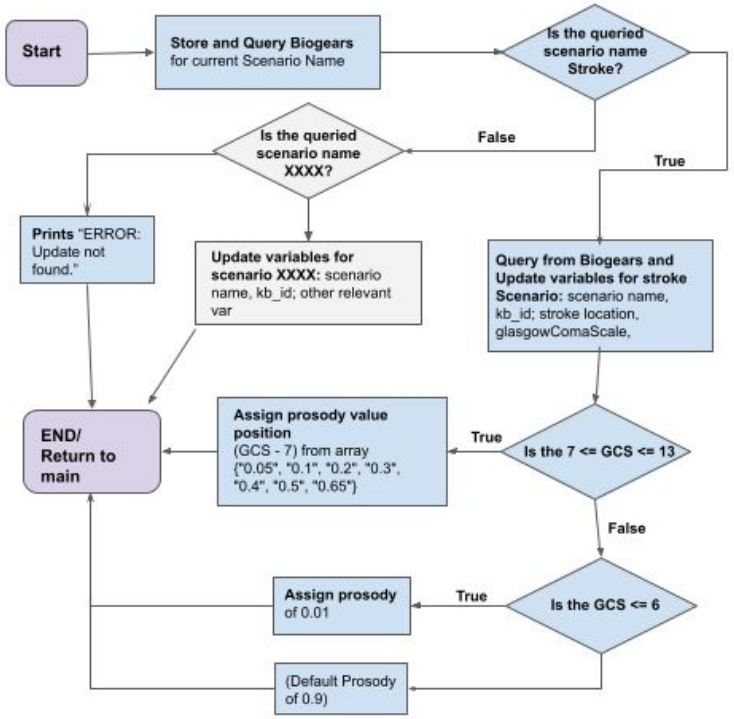
Usability Design Elements

- Visual graphics instructional file as optional download

Patient Constructor Initialization (1st time)



Patient Update Function



Usability Design Elements

- Instructional file included in program download package
  - Summary of program & functions
  - Types of variable inputs and outputs available
  - Program dependencies
  - ‘How-to’ instructions
- Commented Code
- Streamline code editing process

Measurements for Success

Accuracy

Usability

Authenticity

Numbers to Meet

90%

Intent & Query Correctness

90%

Student and Software Engineer Task Completion

< 3 seconds

Response Time

90%

Neurologist Content Satisfaction

Program Accuracy - Summary

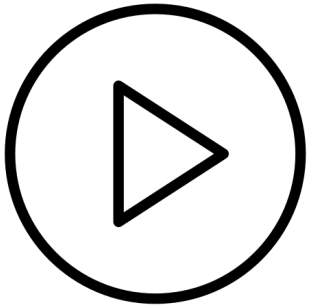
Correct Response Frequency (CRF)

	Verbatim KB Questions	Synonymous KB Questions	Non-KB Questions	Overall
Average CRF	100%	92%	93%	95%

Response Time

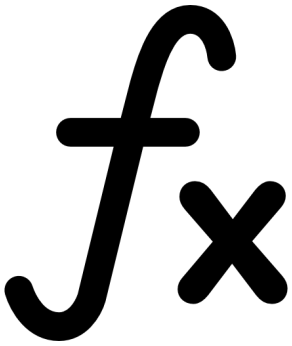
	Trial 1	Trial 2	Trial 3	Overall
Average Response Time (s)	2.732	2.854	2.814	2.800

Student Usability Study: Defining Tasks



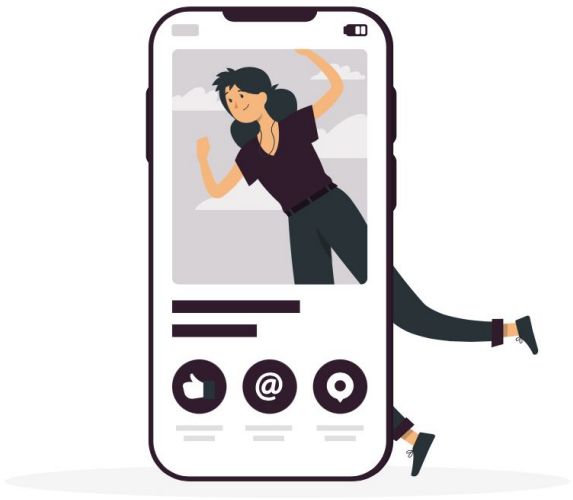
Run NLP Program

Add new Knowledge Base

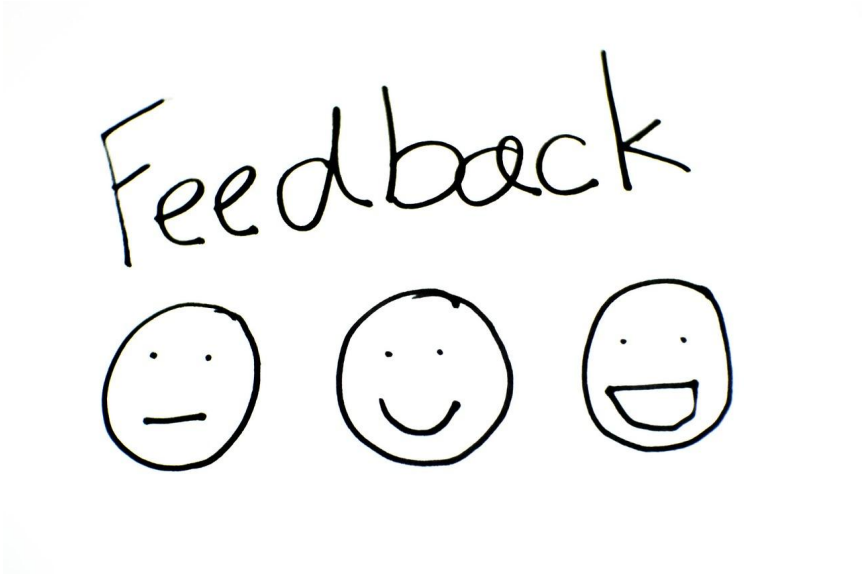


Add a new Function

Results - Student Usability Study

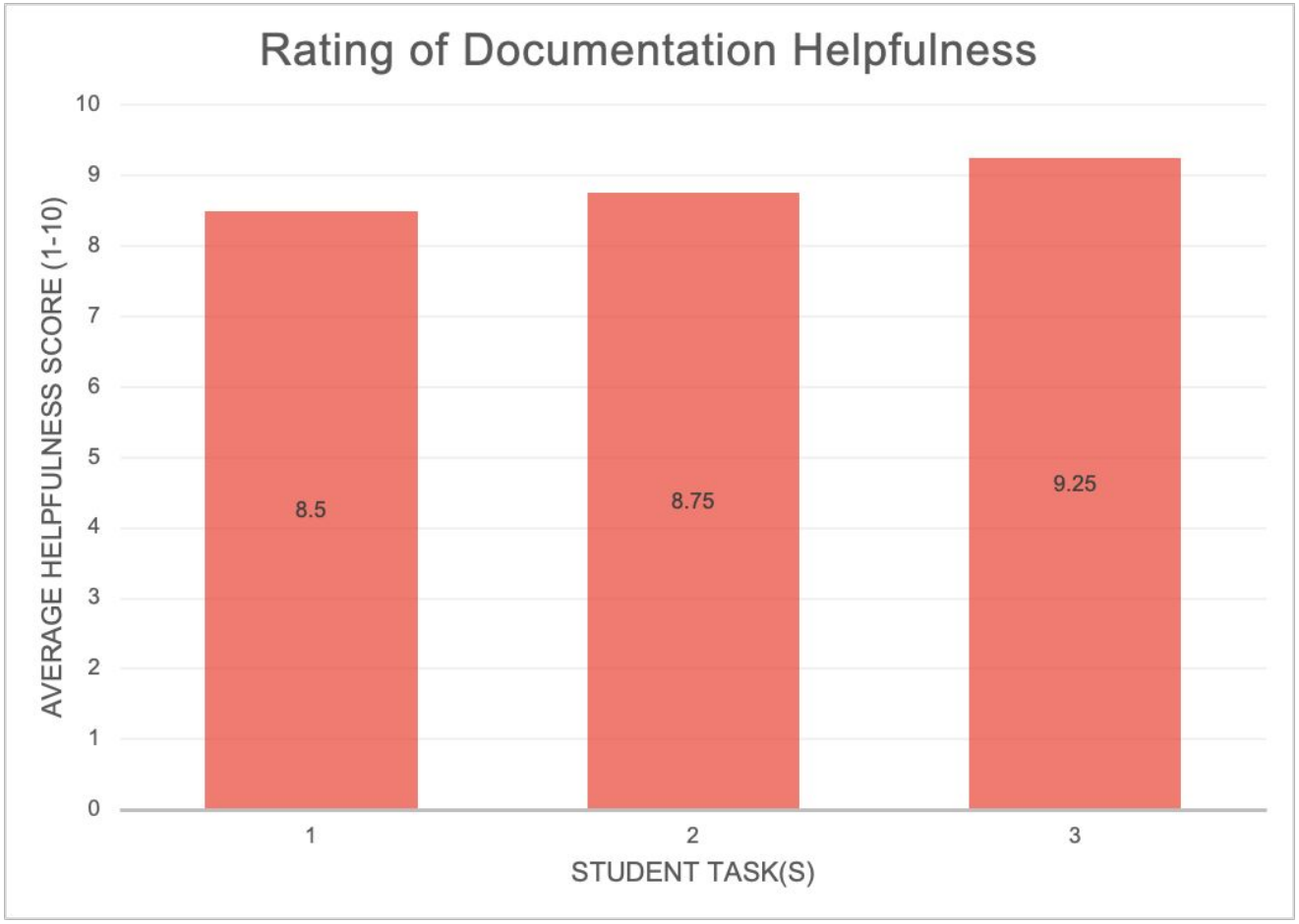


User Profile



User Feedback

Results - Student Usability Study



Ongoing Testing - SE and Neurologist

Usability - Software Engineers (SE)

- Assess and provide feedback for NLP program
- Tasks: Program set-up, knowledge bases, and function alterations, etc.

Authenticity - Clinical Validation

- Assess and provide feedback for response content
- Task: Diagnose different stroke locations and GCS from simulated patient interaction

Future Works

- Feedback from usability study
- Expand the current questions and answers
- Addition of dynamic functions
- Addition of more scenarios
- Adapt patient response with more than one scenario
- And more...

Acknowledgements

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References

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(3) Dikmen, S., Machamer, J., & Temkin, N. (2017). Mild Traumatic Brain Injury: Longitudinal Study of Cognition, Functional Status, and Post-Traumatic Symptoms. Journal of neurotrauma, 34(8), 1524–1530. https://doi.org/10.1089/neu.2016.4618

(4) Wäljas, M., Iverson, G. L., Lange, R. T., Hakulinen, U., Dastidar, P., Huhtala, H., Liimatainen, S., Hartikainen, K., & Öhman, J. (2015). A prospective biopsychosocial study of the persistent postconcussion symptoms following mild traumatic brain injury. Journal of neurotrauma, 32(8), 534– 547. https://doi.org/10.1089/neu.2014.3339

(5) Jacobs, B., Beems, T., Stulemeijer, M., van Vugt, A. B., van der Vliet, T. M., Borm, G. F., & Vos, P. E. (2010). Outcome prediction in mild traumatic brain injury: age and clinical variables are stronger predictors than CT abnormalities. Journal of neurotrauma, 27(4), 655–668.

(6) Powell JM, Ferraro JV, Dikmen SS, Temkin NR, Bell KR. Accuracy of mild traumatic brain injury diagnosis. Arch Phys Med Rehabil. 2008 Aug;89(8):1550-5. doi: 10.1016/j.apmr.2007.12.035. Epub 2008 Jul 2. PMID: 18597735

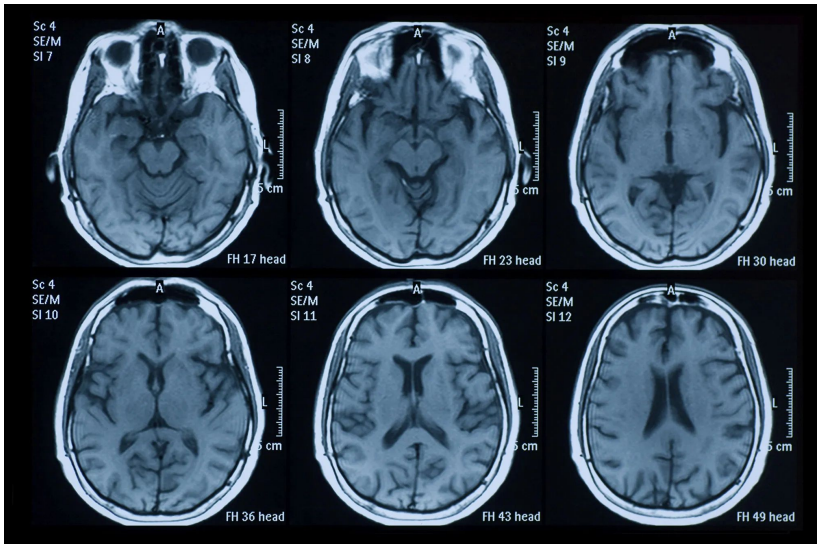
Questions?

Appendix

Traumatic Brain Injury: Defining the Problem

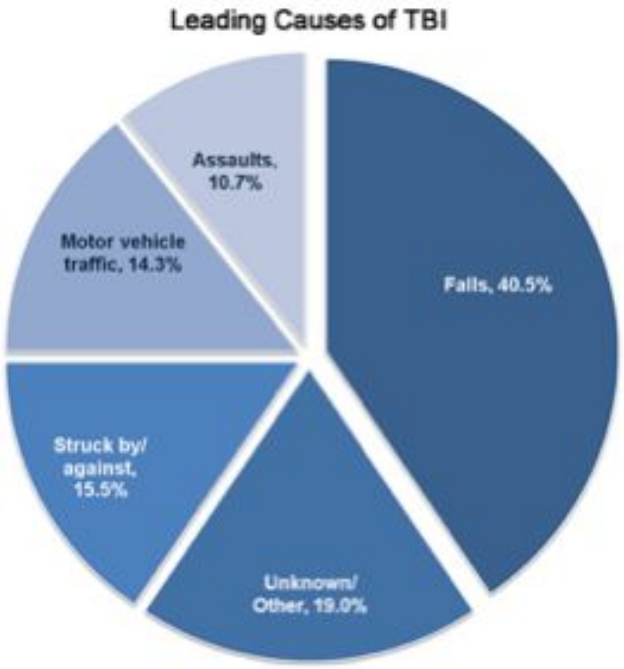
- Traumatic Brain Injury (TBI) is an alteration in brain function caused by an external force
- TBI is considered the **leading cause of death** and disability among children and young adults in the United States
- The average cost of medical malpractice is **$668,000 per case** with annual costs ranging from $1.56 billion to $5.6 billion

Current Diagnostic Methods



- Imaging Tests: Computerized Tomography (CT), Magnetic Resonance Imaging (MRI)
- Nerve Function Test
- Blood tests
- Glasgow Coma Scale
- Speech and language tests

Medical Errors + TBI



- Misdiagnosis
  - Approximately **12 million people** in the U.S. seeking outpatient medical care experience some form of diagnostic error
  - Fifty-six percent of mild TBI cases identified by study personnel did not have a documented mild TBI-related diagnosis in the ED record.
- Associated cost
  - The average cost of medical malpractice is $668,000 per case with annual costs ranging from $1.56 billion to $5.6 billion

Ongoing Testing - Program Accuracy

- **Average Response Time**
- **Methodology:**
  - Ask a set of 20 randomized verbatim questions
  - Set timer in program
    - Start: Question received
    - End: Response begins
    - Print times

$$t = \sum T / N$$

t = Average time per response
T = time for response
N = 20 questions

Ongoing Testing - Program Accuracy

- **Methodology:**
  - Ask a set of 20 questions and calculate CRP%
- **Categories**
  - Verbatim Questions (Baseline)
  - Synonymous Questions
  - Random Questions

CRP % = C/ N x 100%

C = Number of Correct Response
N = 20 questions

Planned Assessment

Usability - SE	Authenticity - Neurologist
• Percentage of task completion • Mean ratings and standard deviation for documentation clarity • Number of reported errors	• Percentage of error of diagnosed GCS • Percentage of correct stroke location diagnosis • Bernoulli trial for expected error question
• Summary of future improvements and errors	