

Case-Based Reasoning to Aid in Clinical Decision Support of TBI

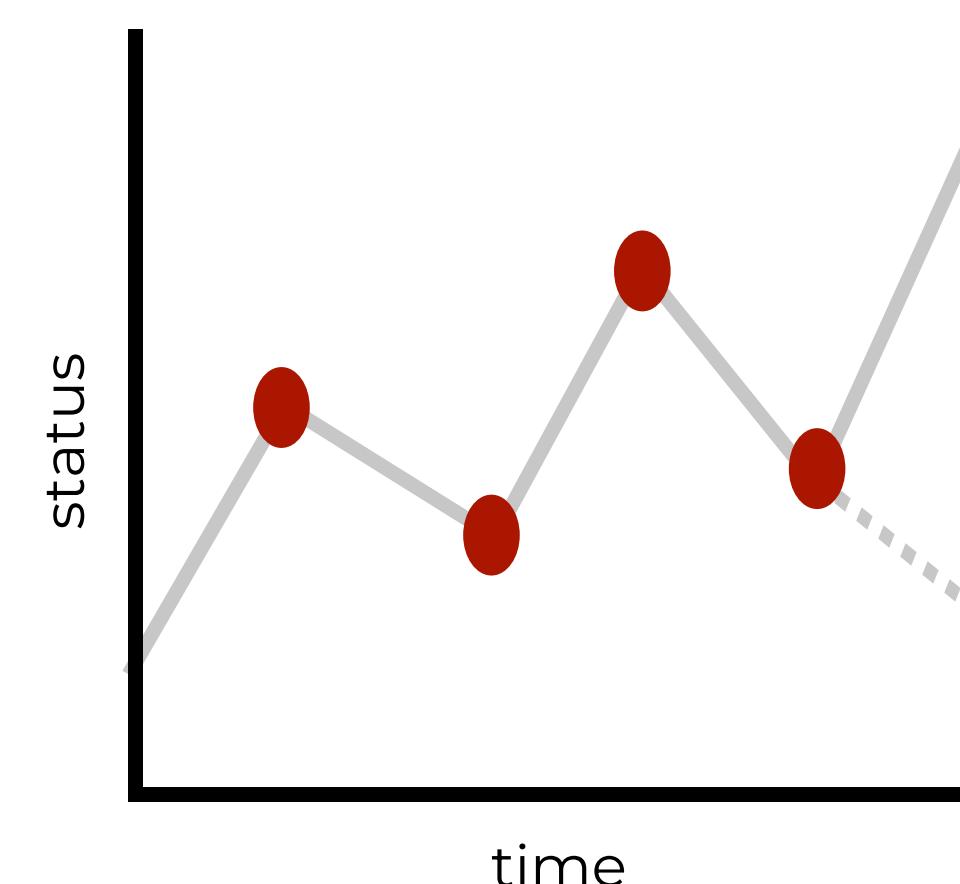
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NEED

Traumatic brain injury (TBI) is a leading cause of death and disability in the US, resulting in an estimated 288,000 hospitalizations a year.

'Intermediate endpoints' refer to preventative events that correlate with a patient outcome.

- Predicting whether these events will occur will help neurosurgeons with treatment planning.



Objective: To build an interoperable system that delivers precision medicine and data-driven clinical decision support for the management of moderate to severe TBI.

DESIGN INPUTS

Key Constraints

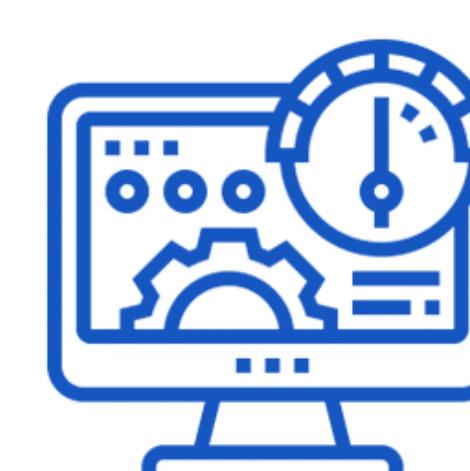
TRACK-TBI: 2,838 patients with time series, medical record, imaging, etc. data.

Scope of data set is limited to what is acquired in a hospital (FDA-cleared devices, medical records, etc.).

Requirements

System Performance:

- System performance for TBI patient outcomes trajectories.
- Mean Absolute Percent Error (MAPE) $\leq 32\%$.



Reliable Usability:

- 100% reliability** in generating reproducible outcomes.
- Customization capability for all low-risk components.

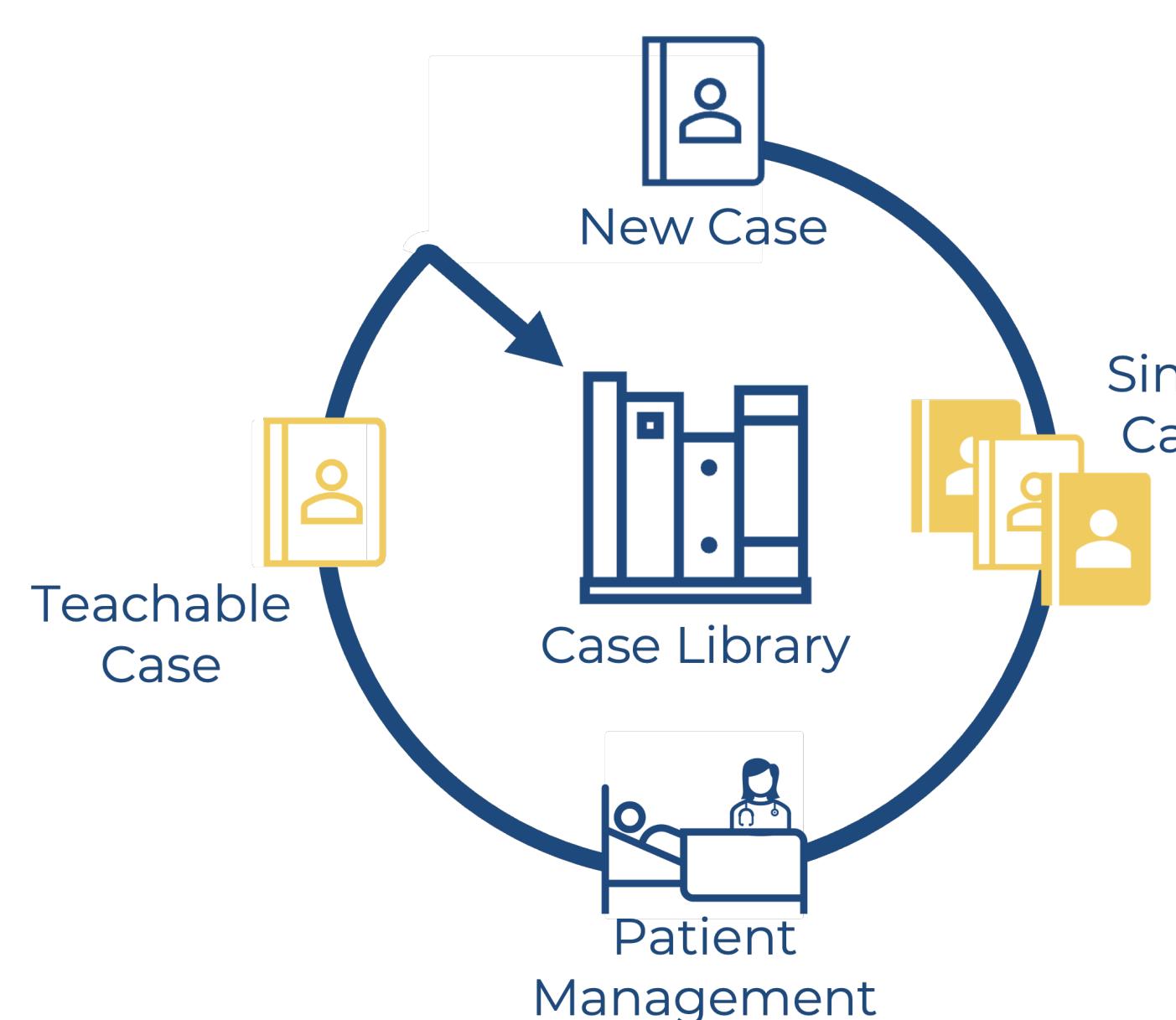


Latency:

- Maximum response time ≤ 300 ms.
- Ensures swift system interactions for clinicians.



SOLUTION



Case-Based Reasoning

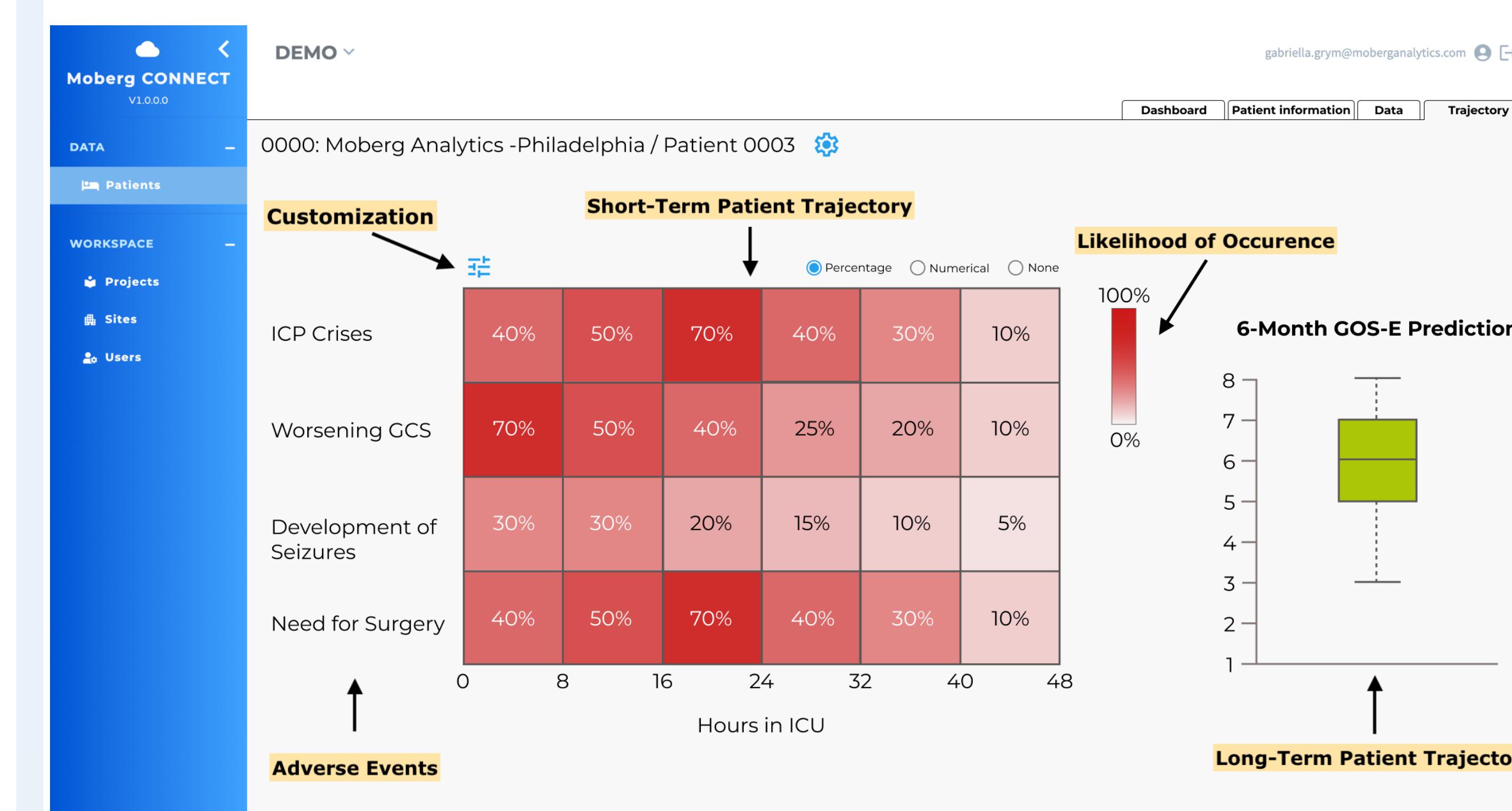
- Stores & retrieves clinical trajectories of past cases to plan treatments for new patients.
- An "active learning" system that evolves by integrating findings from each new patient.

C2: Patient Database

- Allows for retrieval of clinical data for patients of interest



C1: Website



VERIFICATION

Performance Test

- Pass Criteria: If the MAPE, calculated from the LOOCV process, is $\leq 32\%$ for the prognostic system's predictions of patient outcomes.

$$\text{MAPE} = \frac{1}{N} \sum_{i=1}^N \left| \frac{Y(IE_i, T_i) - p(IE_i, T_i)}{Y(IE_i, T_i)} \right| \times 100\%$$

System Reliability Test

- Pass: Criteria: if reliably generate reproducible results allowing 100% customization of identified low-risk components.

Latency Test

- Pass Criteria: Response times ≤ 300 milliseconds across all endpoints.

Step #	Step Description	Expected Outcome	Actual Outcome	Pass/Fail Criteria
1	Initiate API call to retrieve patient data.	Data returned within 300ms.	PASS	Pass if < 300ms; Fail if $\geq 300ms$.
...
5	Execute API call during peak system load.	Response time maintained under 300ms.	FAIL	Pass if < 300ms; Fail if $\geq 300ms$.

Results: Single Request (100 trials)
latency = $0.02 +/- 0.0029s$

Results: Peak Load Test (100 trials)
latency = $1.31 +/- 0.3647s$
min = $0.68s$
max = $1.76s$

FUTURE WORK

- Expand feature set
- Validate the model using an external data set
- File an Investigational Device Exception (IDE) to test the system in a clinical environment at Penn
- Obtain additional feedback from broader set of users

REFERENCES

- Cheng, F., Pan, Y., Zhao, L., Niu, Z., Guo, Q., & Zhao, B. (2022). A Machine Learning-Based Approach to Predict Prognosis and Length of Hospital Stay in Adults and Children With Traumatic Brain Injury: Retrospective Cohort Study. Journal of Medical Internet Research, 24(12), e41819-e41819. <https://doi.org/10.2196/41819>

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