Using Contextual Data to Enhance Machine Learning in Traumatic Brain Injury: Progress from the MIND Workgroup

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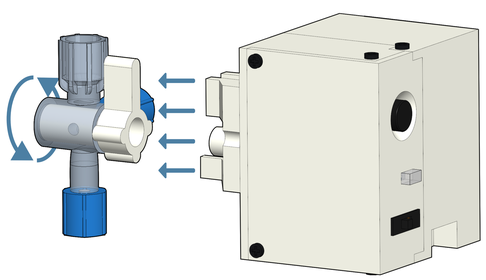
INTRODUCTION

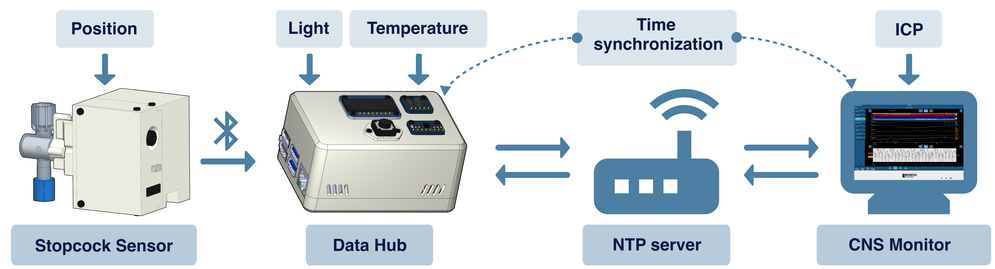
- Contextual data is rarely factored into analytic methods used in physiological event detection or prediction.
- Many traumatic brain injury (TBI) patients experience elevated intracranial pressure (ICP).
- An external ventricular drain (EVD) is placed in the ventricles of the brain to control the pressure by draining cerebrospinal fluid (CSF).
- ICP values are recorded continuously but are only valid when the stopcock is in the “off to drain” position (CSF flow directed into a pressure transducer).
- We report here a method to record the EVD stopcock position to provide critical information about the reliability of ICP measurements.

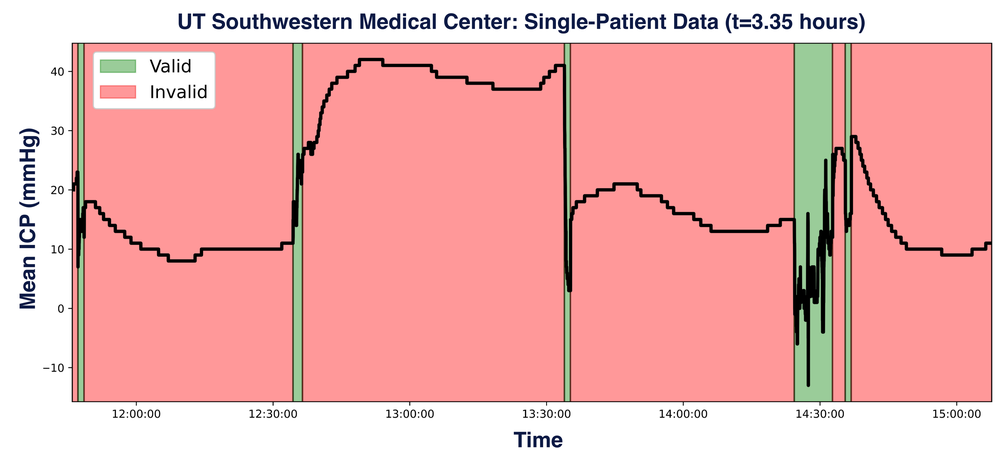
METHODS

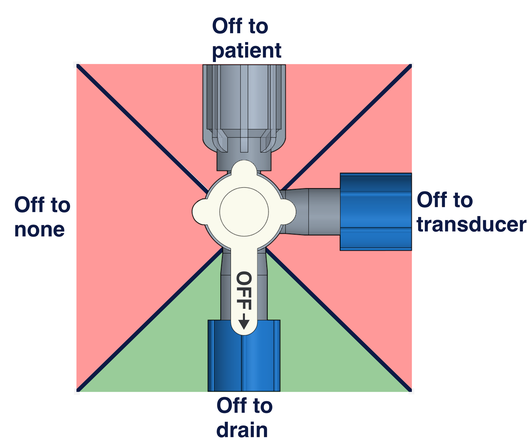


- The Stopcock Sensor measures the stopcock position (1 Hz) and transmits it via Bluetooth to the Data Hub.
- The Data Hub aggregates data from the Stopcock Sensor and on-board light and temperature sensors into files.
- The Network Time Protocol (NTP) server time-synchronizes the Data Hub and CNS Monitor which receives measured ICP values.
- Data was collected from an IRB-approved trial at UT Southwestern Medical Center (n=3, t=12.14 hours).
- No changes were made to the patient’s standard of care other than inclusion of Stopcock Sensor and Data Hub use.

RESULTS







EVD stopcock position	Percentage of time (t=12.14 hours)
Off to patient	0.15% (0.02 hours)
Off to transducer	95.66% (11.61 hours)
Off to drain	4.19% (0.51 hours)
Off to none	0.00% (0.00 hours)
ICP standard deviation: region comparison	
Valid region	5.76 mmHg (avg)
Invalid region	3.60 mmHg (avg)

CONCLUSION

- We successfully synchronized contextual data (stopcock position, ambient light/temperature) with physiological data.
- We clinically validated the Stopcock Sensor and Data Hub.
- This system enables investigations into the effects of contextual factors on physiology, patient outcomes, and machine learning models.

FUTURE WORK

- Continue patient enrollment and data collection in the UT Southwestern Medical Center clinical trial.
- Compare machine learning model accuracies trained on unlabeled and valid/invalid-labeled ICP datasets.
- Integrate additional contextual data sources such as ambient noise levels and nursing annotations.
- Extend context to battlefield settings e.g. prolonged casualty care and medical evacuation.

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