Unsupervised Human Fatigue Expression Discovery via Time Series Chain

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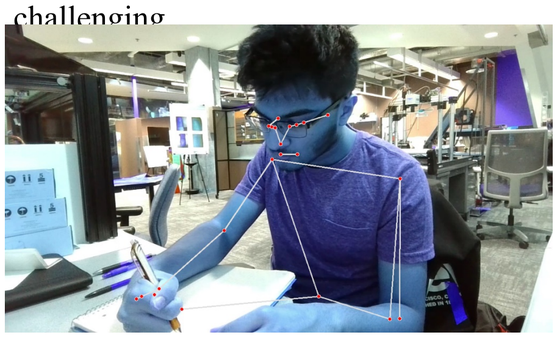
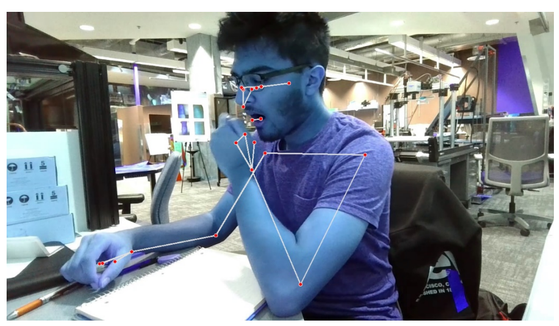
Problem Statement

- In today's demanding work environment where long work hours are common, the need for continuous fatigue monitoring becomes paramount in ensuring safety in professional settings.
- However, data scarcity, the lack of timely labels, and the complexity of fatigue as a psychological and physiological state makes continuous fatigue detection highly challenging.



Student working in ergonomic setting

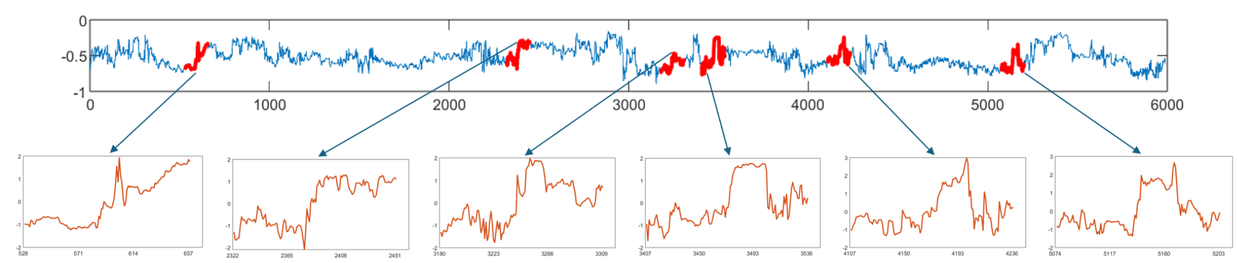


Yawning as a sign of fatigue

- To tackle the challenge of fatigue detection, we propose an unsupervised pipeline leveraging data from a single video source to identify evolving expressions for potential signs of human fatigue using robust time series chain discovery.

Robust Time Series Chain Discovery

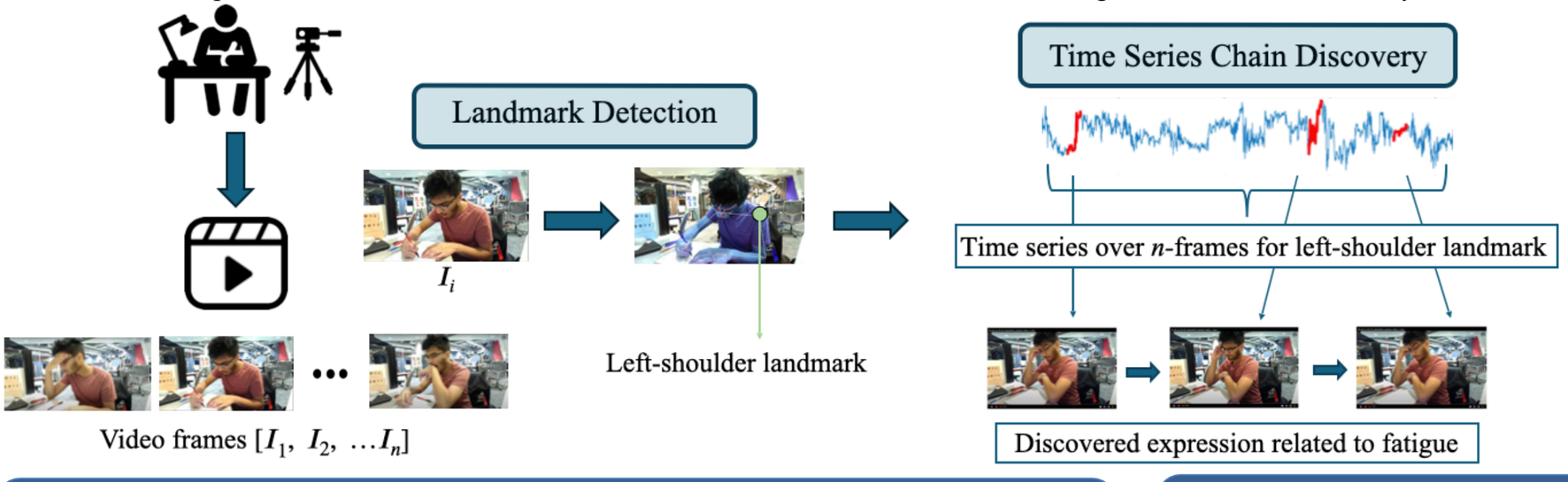
- Time series chains are effective high order time series primitives that represent a series of interconnected events over time[3].
- **Robust time series chain discovery** is a method to identify evolving trends within a dataset over time by discovery similar chains corresponding to a particular event[1].
- In the context of fatigue expression discovery, time series chains capture the dynamic evolution of human behavior over time, offering valuable insights into patterns indicative of human fatigue onset.



Fatigue patterns detected by time series chain discovery algorithm for landmark 11 (left shoulder)

Experiment and Results

- Collected three 10-minute videos of sedentary subjects working in ergonomic environments, including two videos showcasing the subjects in a fatigued state, using a 720p webcam angled at 45 degrees. Extracted frames from these videos at a rate of 10 fps to serve as input to the **pose landmark detection** model[2], capturing 3D spatial information of the eyes, shoulders, and mouth.
- Applied robust time series chain discovery algorithm with a subsequence length of 130, representing an action length of 13 seconds, on depth spatial data of mouth and shoulder landmarks.
- Detected expressions indicative of signs of fatigue, such as **yawning while writing**, reflected in spikes within the first, second, and third discovered chains. Additional signs of fatigue were observed in the spikes of the fourth, fifth, and sixth discovered chains with the student rubbing his forehead, nose, and eyes in tiredness.



Detected corresponding video captures for left shoulder

References

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Contributions and Future Work

- Innovative **unsupervised** method leveraging robust time series chain discovery to uncover evolving expression patterns indicative of fatigue in real-world fatigue scenarios.
- Demonstrated effectiveness of robust time series chain discovery as a as a low-cost method for identifying evolving behavior in **video data streams**.
- Investigate the integration of machine learning algorithms to further refine the developed unsupervised framework.