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# **CausalCFF: Causal Analysis between User Stress Level**

And

**Contextually Filtered Features Extracted from Mobile Sensor Data** 



Panyu Zhang, Gyuwon Jung, Uzair Ahmed, Uichin Lee

### KAIST

## Graduate School of Data Science, School of Computing

# Introduction

**Background:** Mobile technologies now enable the delivery of interventions to improve users' mental and physical health. Causal analysis helps researchers identify potential causes of health issues and design appropriate interventions

**Research Gap:** Prior studies have mainly focused on simple sensor-to-outcome relationships (e.g., walking activity duration  $\rightarrow$  perceived stress). There is a gap in causal analysis of more complex behavioral features derived from multiple sensor signals and linked to well-being labels.

**CausaICFF:** It is a proposed framework that investigates causal links between contextually filtered behavioral features (e.g., walking duration at workplace locations) and well-being outcomes (e.g., stress).



Codebase

**Key Finding:** Frequent workplace visits during periods of reduced home time emerge as the strongest cause of elevated stress levels. Such causal relationship differs across users.



## Main contributions:

- Extending Mobile Sensor Data Causal Analysis from Unimodal Features to Multimodal Features. To the best of our knowledge, our work is the first to conduct causal analysis between user self-reported well-beings and multimodal features. To fill the gap, we combine contextually filtered feature extraction and convergent cross mapping.
- Opensource Framework for EASY Replication. We open sourced the CausalCFF framework.

## Key takeaways:

- Human behavior which may result in stress is more than single sensor feature. The top causers for stress is composed of multimodal features aside from unimodal features.
- Such multi-modal causers for stress are diverse across people. Even for the top multimodal causer for stress, its causal impact diversifies across people.



# Results

## Findings:

- Top Contextually Filtered Causer for Stress: A high frequency of visit for workplace, combined with limited time at home, may lead to stress
- Personal Difference in Terms of Causal Relationship: Even for the top 1st feature, only 9 out of 24 users exhibited a statistically





Step Count Location = Gym

### **Association Rule Mining:**

In order to extract the association across different modalities, we can use association rule mining.

**Step 1.** We can mine the association rules from the multi-modality data. Say, high step count conditioned on gym location.

**Step 2.** Given the association rules, we will use antecedent of the rule as context and consequent of rule as feature and calculate the contextually filtered features. Say, we can calculate the step counts given gym location.



Mean/Std of Step Counts | Location = Gym

#### **Contextually Filtered Feature (CFF) Extraction:**

Given the association rule, we can identify the time windows when time spent at gym is high and calculate the mean/std of step counts in those windows.



Finally, this is the overall framework of CausalCFF, we conduct the causal analysis between contextually filtered features and stress level.

significant causal relationship with stress levels



0.000 0.025 0.050 0.075 0.100 0.125 0.150 0.175 0.200 Causality Correlation

## **Top Contextually Filtered Causers for Stress**



Causality of Top Contextually Filtered Causer for Stress Across Different Users

