BASS: Towards Behaviorally Adaptive Software Systems

Abstract

The goal of the following research proposal is to enable software systems to adapt towards users behavior and interaction patterns by providing a generally applicable architecture making use of physiological data. The proposed architecture mainly comprises a central reinforcement learning engine which uses few- or single-episode policy transfer to adapt to new users and domains as well as interconnected lightweight edge-cloud stream processing components for tailored preprocessing.

Goal & Use Cases

Innovations in machine learning, steam processing and new sensors to capture physiological data enable a fundamental change in user experience not only for consumer- but also of business-facing software systems[1]. Making use of these new insights, software systems can truly focus on showing users the most suitable content as a result of the unfiltered feedback they get through physiological data. Collaborative filtering systems in online shops can be complemented by the physiological response users show towards products which can increase the conversion rate and consequently product sales. Furthermore, when interacting with business software, this offers the possibility to adjust the workload to the current cognitive load[2,3] and state of attention of the individual user. This can improve productivity/decrease mistakes whilst increasing the joy of use.

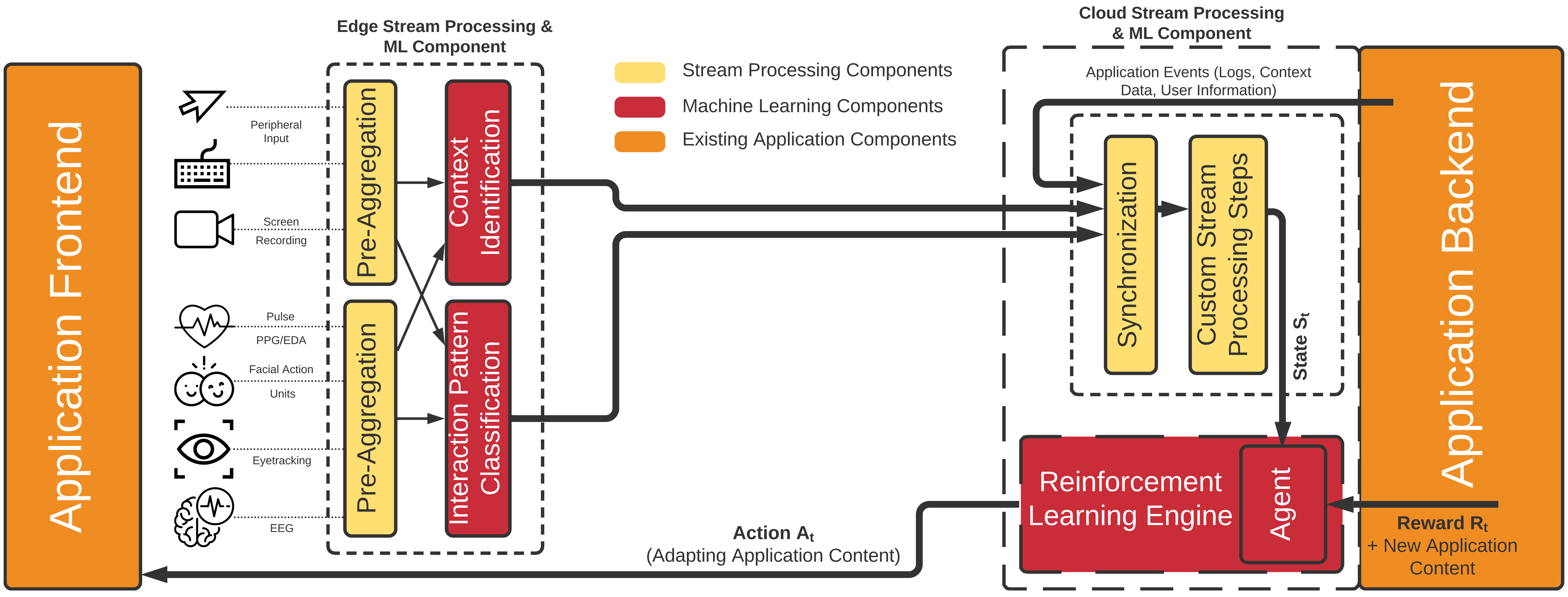
Problems

Physiological data is sensitive health-related information and must therefore be processed securely and under strict rules and precautions (see GDPR[4]). Furthermore, collecting physiological data in a streaming-fashion implies an increased amount of data to be processed and transferred over network, which must not increase the latency of the client or the software system. Current implementations mostly concentrate on single devices and use cases with predefined machine learning and stream processing steps. Hence an abstraction for different vendors, sensor types as well as towards different use cases and their requirements for data preprocessing should be ensured to guarantee general applicability.

Solution & Research Project Proposal

A collocation of interconnected lightweight edge-cloud stream processing components, which communicate in a determined fashion is proposed in order to pre-aggregate and adapt towards the use cases and the required data preprocessing. This reduces the data transferred over network since the computation is pushed to the edge and promotes secrecy as well as privacy since only condensed information is communicated (context information and interaction patterns) while taking into account to not overburden the commodity hardware on client-side.

A central reinforcement learning component implementing a single- or few-episode policy transfer[5] is proposed to ensure fast adaption to different users and different domains (use cases) given only limited adaption time and few rewards. The reinforcement learning component is provided with the environment state S_t (result of processing physiological and application data), a reward R_t (provided by the application) and uses this to adjust the presented content (action A_t) which constitutes the overarching inherent feedback loop.



Christian Warmuth
Master Data Engineering 19/20
Hasso Plattner Institute
christian.warmuth@student.hpi.de

Poster for Data Engineering Lecture Series

Comment 1: The inter-component communication between edge- and cloud stream processing & ml components is not part of the diagram presented above for the sake of comprehensibility.
Comment 2: The context identification (here part of the edge stream & ml component) processing amongst other things screen recording data can also be located in the cloud component if the application provides all necessary logs and a precise event stream to comprehend the exact steps of the users interaction. The above presented architecture is based on a brown-field-approach in which the software system does not provide detailed user interaction event logs.
Comment 3: Possible preprocessed information as an output of the edge stream & ml component might be: The user is scrolling through the electronics department of an online shop (context information), skimming over the items with a neutral emotional state (interaction pattern).

References:
[1] "Psychophysiological Indicators for Modeling User Experience in Interactive Digital Entertainment", Čertický et. al., 2019, doi:10.3390/s19050989
[2] "Eye tracking cognitive load using pupil diameter and microsaccades with fixed gaze", Krejez et. al., 2018, ncbi.nlm.nih.gov/pmc/articles/PMC6138399/
[3] "Cognitive Load Theory", Sweller et. al., 2011, Springer
[4] "Health Data", edps.europa.eu/data-protection/our-work/subjects/health_en, accessed last 26.01.2020
[5] "Single Episode Policy Transfer in Reinforcement Learning", Yang et. al., 2019, arxiv.org/abs/1910.07719v2

HPI Hasso Plattner Institut