Leveraging IoT Sensing to Improve Daily Living in Smart Homes

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Internet of things based smart home applications have occupied a considerable place in our everyday life. They are expected to understand human activities and requirements in the recent future and thus assist in addressing the problem of elderly care, young infants and patients requiring post operative care. Specifically, smart homes are equipped with various number of sensors and devices of different categories which generate continuous readings. Proper and error-free processing of these received data by various applications can greatly enhance the functionality of smart home with the potential to analyze and infer the physical health of the resident.

Completion of certain Activities of Daily Life (ADL) such as cooking, eating, daily hygiene reflects good indicators of the well- ness of a person. However, it is difficult to identify the exact subset of sensor events that pertain to a single ADL in the aggregated sensor stream. In other words, while mapping sensor patterns to a single ADL can be modeled as a straightforward classification problem, accurately segmenting sensor streams into events relevant to a single ADL itself is a data intensive task. The problem is exacerbated by the fact that myriad choice of available IoT devices from various vendors (with potential differences in features), would make smart home deployments different from one another. Further, there can be transient and permanent faults in the infrastructural sensors which might generate faulty data. In order to properly leverage the richness of the data produced from the huge pool of sensors, the corresponding ADL detection application also needs to process the data in real time, and check for inconsistencies, if any. The presence of not so useful and erronious data can interfere with the application accuracy as well as speed.

Inspired by the challenges, we broadly divide our work into three parts, a) grouping sensor streams relevant to a single activity into a single transaction, which is to be detected and labeled by a classification algorithm[1], b) finding transient and permanent faults in the sensor stream and provide correct information for various smart home applications, and c) grading the data and cache only the important portion of the data for the classification algorithm to access and process without compromising its accuracy.

Demultiplexing ADL: We analyze various smart home datasets and identify important as well as intricate features of human activities, which are discriminative in nature and hence can be exploited in the heterogeneous sensor event streams. The features are, a) a particular human activity span for a fixed duration, b) not all sensors that trigger together can be used to do a meaningful activity, and, c) the frequency characteristics of sensor events (from a single activity) change when received in conjunction with sensor events from other activities. We then design an efficient technique[1] for event segmentation by exploiting the insights, and combine the segmentation followed by activity detection and a greedy stitching policy to obtain separated Activities of Daily Life (ADL). The segmentation techniques lead to detection performance within 96% of the optimal.

Data Gradation in Smart Homes: In this work, we study the sheer volume of data produced in a smart home and how we can effectively store them and redirect the most useful data back to the monitoring applications. The events triggered by sensors increase multi-fold as the number of days increases (exponential in case of video monitoring). We considers two typical scenarios - infrastructural sensor data (non-multimedia data) and, video surveillance, wearable sensor data collected in a smart home. We devise an algorithm to identify correlated sensors whose readings may be redundant and accordingly implement gradation in first scenario. In second, we spot the activity/inactivity regions in video surveillance and realize that there are complementary zones where performance of video and wearable sensors excel. We use this intuition to grade data. The performance improvement of data gradation is impressive. We achieve a data reduction of 58% and 87% vis-a-vis the complete data in two scenarios respectively, however even with such storage reduction manage to improve accuracy by 4% and 17%. We use the gradation information at file system level, build multiple storage tiers (fast and slow), and organize the graded data into them by lever- aging the existing storage optimization techniques. We obtain substantial runtime improvement (23% and 46% in Scenario Inertial and Scenario VidWear) by (a) modifying placement policies in the storage system to keep only higher grade data in the fastest tier and, (b) transparently serving reduced data of higher grade to the application.

My current research focuses on *understanding transient and permanent faults in infrastructural sensors* deployed in smart homes. Most of the existing works in this area have focused on detecting permanent anomalies in the sensor stream, crowd-sourcing errors from the users present in the home. However, our motivation lies in elderly monitoring and we focus on modeling a complete unobtrusive error-detection system, which can detect permanent as well as transient faults in the data generated in a smart home, and effectively redress the predictions by monitoring applications.

REFERENCES

[1] P. Kodeswaran, R. Kokku, M. Mallick, and S. Sen, "Demultiplexing activities of daily living in iot enabled smarthomes," in *Computer Communications, IEEE INFOCOM 2016-The 35th Annual IEEE International Conference on*. IEEE, 2016, pp. 1–9.