Early illness detection in elderly using sensor networks with TigerPlace case studies

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Abstract

Many older adults in the US prefer to live independently for as long as they are able, despite the onset of conditions such as frailty and dementia. Elderly patients are particularly at-risk for late assessment of health changes due to factors such as their impression that such changes are simply a normal part of aging or their reluctance to admit to a problem. In-home sensors networks have emerged in the last ten years as a possible solution for early illness detection. Several academic projects such as CASAS (Washington State University), TigerPlace (University of Missouri) and ORCATECH (Oregon Health and Science University) have demonstrated the utility of in-home sensors for monitoring elderly but also have shown the necessity of developing new pattern recognition algorithms able to handle large amounts of diverse data also known as big data. In TigerPlace, an aging in place facility from Columbia, MO, we created a unique living laboratory by deploying in-home sensors together with electronic health record (EHR) system developed in-house that integrates clinical and sensor data. In-home monitoring devices such as infrared motion detectors, Kinect depth cameras, Doppler radars and bed sensors capture information related to the behavior of the residents from the monitored apartment and assist the clinical personnel in medical decision making. The goal of this work is to investigate early illness detection (EID) methodologies based on the in-home network sensors and the EHR clinical data. Our methodologies are based on a discrete sensor data representation together with bioinformatics inspired algorithms such as sequence similarity, sequence annotation with medical terms and frequent activity pattern discovery. We will describe and show preliminary results of three EID methodologies denoted as similar abnormal patterns (SAP), missing frequent patterns (MFP) and abnormal frequent patterns (AFP). The output of an EID framework is an alarm (email) sent to the clinical personnel with information related to the nature of the deteced event. SAP is an unsupervised framework in which an alarm is generated if sensor patterns very dissimilar to the ones recorded in the last two weeks are detected. MFP framework is also unsupervised, and generates an alarm if some frequent patterns detected in the past were no longer performed by the resident. AFP is a weakly supervised framework in which an alarm is sent if frequent patterns associated to abnormal days, are currently detected. AFP requires either using the EHR data or labeling of days as “bad”/”good”. In contrast to EID, early illness recognition (EIR) frameworks attempt a more difficult task which is to be more specific about the nature of the disease. We will present an EID framework based on sensor sequence similarity and associated medical terms from the TigerPlace EHR. We will conclude our presentation by describing several research directions enabled by our bioinformatics approach to EIR/EID.