Rapid aging of the population in the US requires increased attention from health care providers and from the entire society as a whole. While the elderly population (aged over 65) will increase by 8% until 2050 in the developed countries, the working-age population (age between 15 and 64 years) will decrease and its ratio to the elderly population will decline from 4.3 to 2.3 [1]. While older adults prefer to live independently, many of the health conditions associated with old age, such as frailty, dementia, and risk of falling require increased attention and monitoring. However, independent living may lead to infrequent health assessments due to lack of continuous monitoring or fear of being institutionalized. Late health assessments may miss unreported complications, which in turn lead to poor long-term prognosis and quality of life [2]. A possible solution to prevent unreported health problems in independently living older adults is through automatic health monitoring systems.

The aim of this dissertation is to use sensor network technology to detect changes in health status of elderly living alone, alert health care providers, and augment traditional health care. We review the Aging In Place (AIP) research and the sensor technology developed at the University of Missouri (MU) to support AIP. AIP represents one’s ability to live in his/her own home safely and independently regardless of age, income, or medical condition.

In this dissertation, we address two topics. First, we discuss the problem of measuring the temporal similarity of two multi-dimensional time series. The second topic of this work is predicting health patterns using time series similarities. For measuring the similarity of multi-dimensional time series, we focus on health care applications. We review already discovered similarity functions for time series. Inspired by the bioinformatics approach, we propose a new method to measure the similarity of two multi-dimensional time series. We introduce the idea of modified Smith-Waterman framework, Temporal Smith-Waterman (TSW), for Early Illness Recognition (EIR) that uses temporal sequences. We analyze the properties of TSW, introduce a faster way to compute it based on genetic programming, and propose a new method for searching
large time series. Our approach doesn’t require series data conversion to continuous format. Instead, we arrange all different sensor hits together with their time stamps into a one-dimensional sequence. Our method overcomes difficulties related to data uncertainty and aggregation that often arise when processing sensor data.

For health pattern recognition, we describe a new framework that uses TSW for abnormal pattern recognition and its application to eldercare and early illness recognition. The new framework for predicting abnormal health patterns uses non-wearable sensors and sensor pattern similarity. A sensor pattern is classified as “abnormal” if it is much less similar to the previous ones. In this work, we consider “abnormal” days as days with documented nurse assessment in the electronic health record. To further refine the nature of the health assessment used in our EIR framework, we proposed a novel semi-supervised for clustering the nursing notes. This method represents each cluster of notes by a language model. We use the bi-grams model of terms to represent term to term dependencies and improve the expressivity of the proposed clustering method. We estimate the cluster model by a maximum a posterior probability (MAP) to address the challenge of highly imbalance nursing visit notes dataset.

In this work, we also propose three methods for identification of deviations in patterns of activities of daily livings (ADL) of older adults and use them to generate alerts for the healthcare providers. ADLs such as bathroom visits can be monitored by automated in-home sensor systems. Our proposed methods find periodicity in sensor time series data using clustering, item set mining, and statistical approaches. A retrospective multiple case study (N=3) design was used to quantify bathroom visits as parts of the older adult’s daily routine, over a 10-day period. The performances of the proposed methods are evaluated using data collected from TigerPlace, an independent living community situated in Columbia, Missouri.