Chapter 5
Towards Behaviour Recognition with Unlabelled Sensor Data: As Much as Necessary, as Little as Possible

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ABSTRACT

The problem of behaviour recognition based on data from sensors is essentially an inverse problem: given a set of sensor observations, identify the sequence of behaviours that gave rise to them. In a smart home, the behaviours are likely to be the standard human behaviours of living, and the observations will depend upon the sensors that the house is equipped with. There are two main approaches to identifying behaviours from the sensor stream. One is to use a symbolic approach, which explicitly models the recognition process. Another is to use a sub-symbolic approach to behaviour recognition, which is the focus in this chapter, using data mining and machine learning methods. While there have been many machine learning methods of identifying behaviours from the sensor stream, they have generally relied upon a labelled dataset, where a person has manually identified their behaviour at each time. This is particularly tedious to do, resulting in relatively small datasets, and is also prone to significant errors as people do not pinpoint the end of one behaviour and commencement of the next correctly. In this chapter, the authors consider methods to deal with unlabelled sensor data for behaviour recognition, and investigate their use. They then consider whether they are best used in isolation, or should be used as preprocessing to provide a training set for a supervised method.

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1. INTRODUCTION

There are many reasons to want to recognise human behaviours, depending on the application, the particular scenario currently occurring, and the information that we can obtain from that scenario. This chapter views human behaviour recognition as the task of finding a mapping from a stream of sensor information to a sequence of recognised activities performed by the inhabitant of a smart home, with the aim of the home being to monitor their behaviour and detect illness or potentially dangerous behaviour. We aim for a general method of identifying the mapping that is independent of the particular sensors that are used, although obviously, precisely what information is available will change the potential behaviours that can be detected. For a smart home, the behaviour itself is performed by the inhabitant, and the sensors detect (potentially noisy) evidence of that behaviour. The task of human behaviour recognition is thus the inverse problem of identifying behaviours from sensors, and the properties of this inverse mapping are of interest. In the ideal case, we would like to be able to map a sensor stream uniquely to a sequence of behaviours (as depicted in Figure 1a), but this is only possible if there is no ambiguity in the sensor stream, which is rather unlikely.

Ambiguity in the sensor information can have several causes. In the extreme case, in which we only have a simple motion sensor in the room where activities take place, we can only infer that some action is or is not happening in that room. In this ‘burglar alarm’ scenario, we would map sensor information either to the set of all possible behaviours, indicating that the inhabitant is involved in some activity, or to a ‘null’ behaviour, indicating that the inhabitant is not involved in an activity (Figure 1b). Although this might provide some valuable information (e.g., that the inhabitant is conscious), it is often not sufficient for the tasks that a monitoring smart home is supposed to fulfill. For example, we would not be able to determine whether the inhabitant has taken regular meals, has followed adequate hygiene routines, or has not put themselves in a dangerous situation.

Figure 1. Different mappings between sensor information and behaviours