Metamodels for complex structured objects classification

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Abstract

The development and proliferation of various portable sensors poses new challenges for analyzing and finding meaning in this data. In our work we investigate classification of complex structured objects. One of the main problems in this task is to generate meaningful and relatively small set of features. We compare several approaches for feature extraction such as expertly defined features, autoregression model and SSA. We propose a new feature generation algorithm, based on local spline approximation. The experiment is conducted on two datasets for human activity recognition using accelerometer.

Introduction

This project is dedicated to multiclass classification of complex structured objects (i.e. we don't have feature representation suitable for direct classification). The problems in this area include human activity recognition from accelerometer time series [1–3], multimedia indexing [4] and recognition of people activity in smart homes [5].

We investigate classification of accelerometer time series. New methods in this field range from topological data analysis [6] to using convolutional neural networks [7]. The extensive survey of methods and datasets for this problem can be found in [8]. In our work the data is time series of acceleration from three axis, which is sensed by mobile phone or other portable device with accelerometer. The problem is to predict the activity a person is performing. List of activities includes walking, running, sitting or walking up/down stairs. In this setup time series are regarded as complex structured objects without explicit feature description. This

* The main problem to tackle is the lack of computational resources, memory and energy ~~of mob.~~ in wearable devices.

~~This appr. The proposed approach~~ This investigation proposes an approach to generate features of time series as complex-structured objects. ~~It brings~~ The generated features bring adequate quality of classification and require moderate recources.

is reasonable because we can't operate with original features as time series might be of different size, not aligned or even multiscaled [9].

The problem of classifying complex structured objects is split in two distinctive procedures. First, we need to extract informative features, and then we use those features as input to some classifier to obtain final model. For simplicity, we assume that these two procedures can be built and analyzed separately. In our project we focused mainly on comparing different methods of feature generation [10, 11].

The first approach for feature generation is calculating expertly defined functions of time series [12]. These functions include average value, standard deviation, mean absolute deviation and distribution for each component. We consider this approach a baseline, as it is the simplest method we use.

We compare baseline with more sophisticated parametric feature generation methods, in which we build approximation models and use their parameters as our final features for classification. In this paper we propose using local spline approximation for feature extraction. In this setup features are knots and parameters of optimal cubic splines approximating our data. We compare this method with other well-known methods for extracting features from time series. One of them is autoregressive model [13]. For each time series we build parametric model and use those parameters as features for classification. Another approach is the model of singular spectrum analysis of time series [14]. We use eigenvalues of trajectory matrix as features for building classifier.

The experiment was conducted on two real accelerometer datasets [15, 16]. We compared the performance of stated feature extraction methods, as well as different classification algorithms. The latter include logistic regression, random forest and SVM.

Problem Statement

Let $\mathcal{S}$ be a space of complex structured objects, Y is a finite set of class labels. We consider accelerometer time series as complex structured objects. Time series is represented as the vector with fixed length T:

$$s = [x_1, \ldots, x_T]^\mathsf{T} \in \mathcal{S}. \tag{1}$$