Behavior analysis of sports and manual labor with wearable accelerometers

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Methods of machine learning for user behavior analysis and classification

The current generation of wearable devices, such as cellular phones, watches, ear-buds and music players, incorporate various types of sensors, including accelerometers, light sensors, cameras, microphones and GPS sensors into their IMU modules. The sensor signals can be applied for analysis of everyday human behavior. One its important part is human physical activity. It reflects various aspects of health and thus is exceedingly attractive for many applications in the field of health-care and manual labor safety monitoring.

We propose methods for human physical activity recognition using time series, collected from a tri-axial accelerometer and gyroscope of a wearable device. Methods solve the problems of time series segmentation, feature extraction and user state classification. We assume that each meaningful segment corresponds to one fundamental period of motion. To perform an adequate behavioral analysis we represent time as a hierarchical structure. It splits a motion, an action, and a process.

Source: Oceancontrols

Behavioral analysis framework

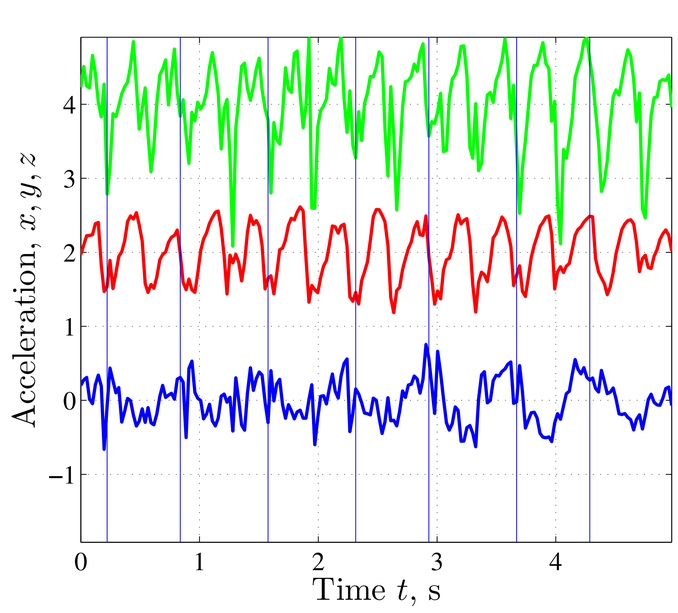
Behavioral analysis outcomes:

1) sequential daily classification on hierarchically-segmented time scale,
2) forecasting of user behaviour and user state alarming,
3) correction and specification of user GPS position under condition of weak satellite signal.

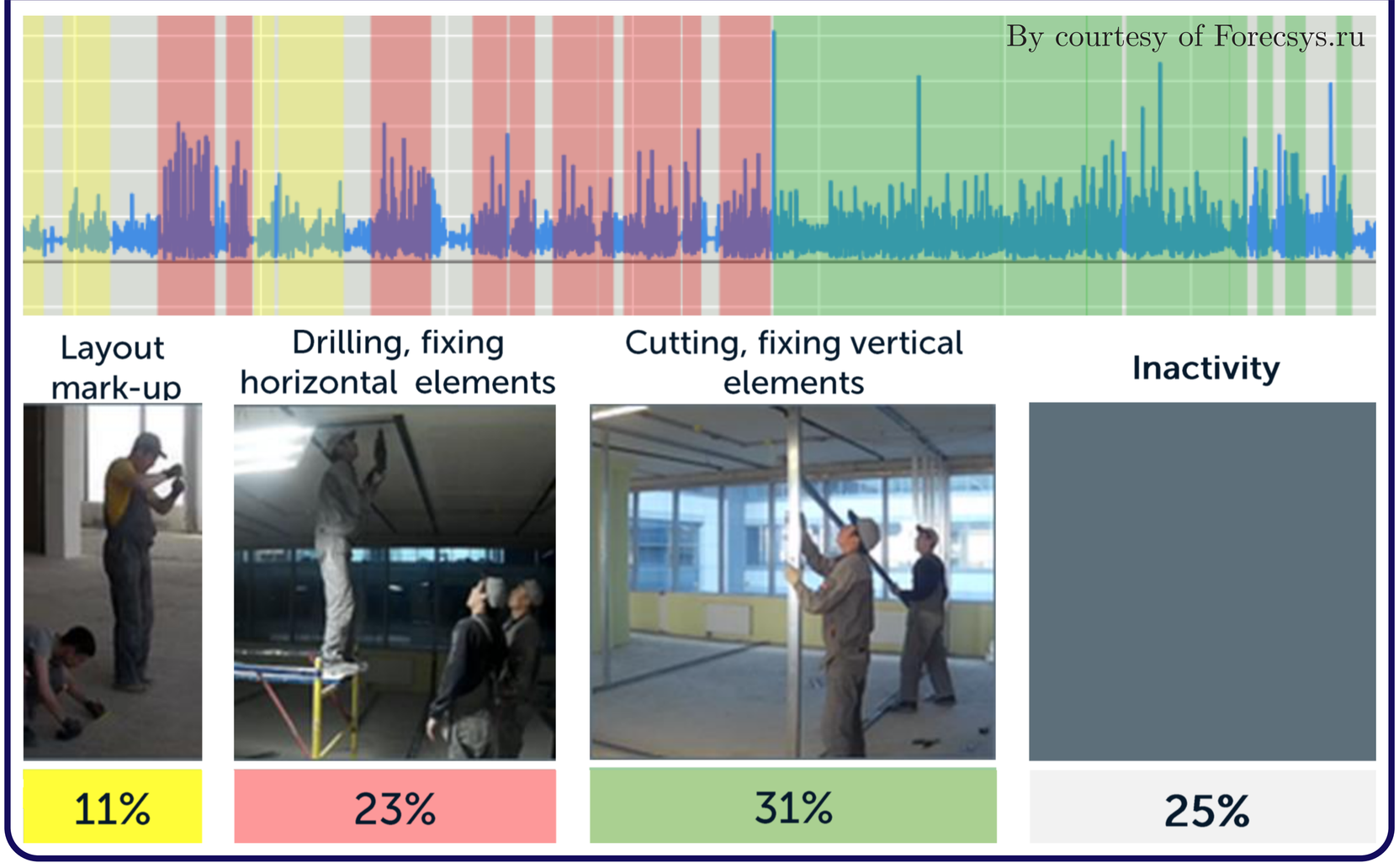
The problem is to process time series in high dimensions under small resources of wearable devices.

Tri-axial accelerometer sources

Our purpose is to perform human physical activity recognition using data, collected from the built-in tri-axial accelerometer of a mobile phone. This data represents quasiperiodic time series corresponding to one of performed activities: walking, jogging, stair climbing, sitting or standing. For each time series we have to detect the correspondent activity type [?, ?].

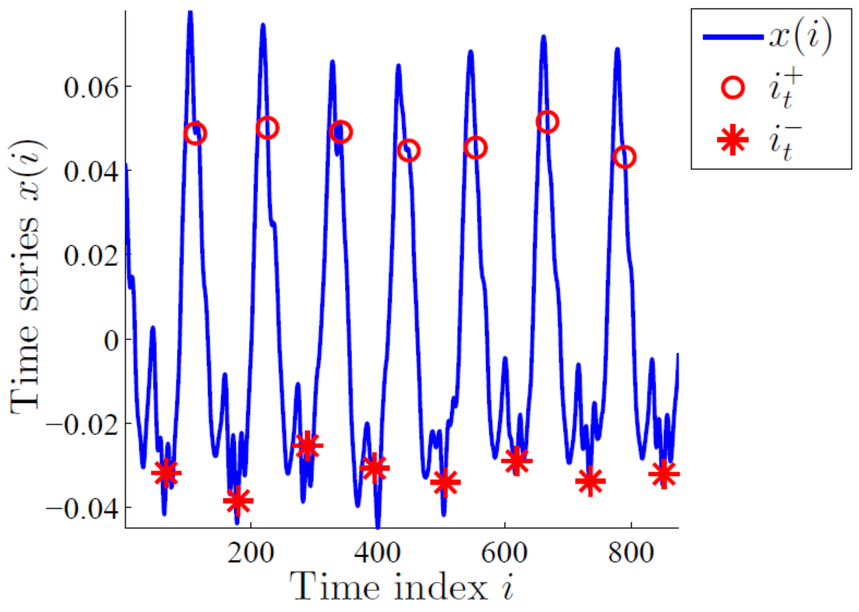


Physical activity analysis is based on hierarchical time representation

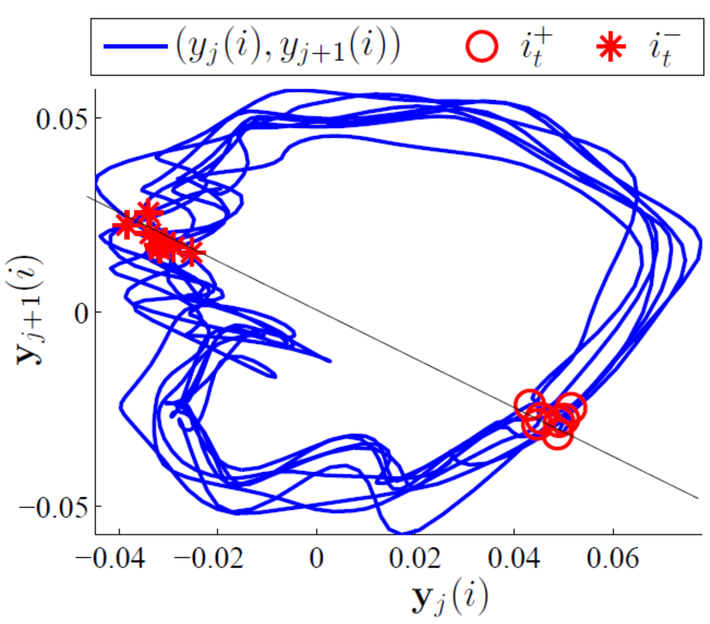


Extracting fundamental periods

We introduce a new definition of nearly periodic time series via triplets ⟨*basic shape, shape transformation, time scaling*⟩ that covers a wide range of time series. To split the time series into periods we select a pair of principal components of the trajectory matrix. We cut the trajectory of the selected principal components by its symmetry axis, obtaining half-periods to merge into segments [?].



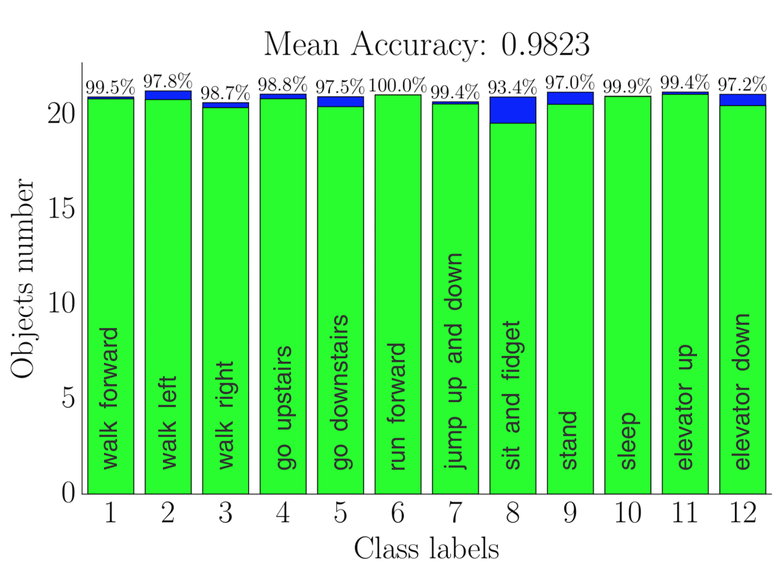
Quasi-periodic time series



Phase trajectory to set stable periods

Performance of classification

Feature-based approach that uses meaningful and concise representations for feature space construction is applied. The time-series approximated by parametric models and their parameters are used as time-series features.



Performance of the human physical activities classification on USC-HAD dataset [?].

References

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