Motion-pattern recognition using wireless sensors

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Abstract. Human motion is a complex process involving the entire psychophysical system. Its analysis helps understand the specific activity and behavior in general better and more completely.

In motion analysis we strive to identify different motion patterns. They can be defined as a process of identification and classification of certain modes of motion, based on various details of motion.

Due to their wide applicability in the past decades, motion-pattern recognition has been a subject of many studies. One of the first motion-pattern recognition methods was based on the use of lighting and markers in order to capture motion with a camera.

The current state of the art enables advanced motion-capture methods. The development and availability of various low-cost wireless sensors, such as accelerometers, gyroscopes and a variety of biomechanical and physiological sensors and powerful processors at the same time open the way for quicker and more efficient motion-pattern recognition procedures.

If such sensors are equipped with a wireless communication module while securely and unobtrusively fixed to humans, they become useful for capturing data of a wide range of motion, even outdoor, and provide biological feedback based on recognized motion patterns.

The main objective of the doctoral thesis is to answer how signals of different wireless sensors can be combined and effectively used to recognize motion patterns. In doing so, development of new appropriate procedures for fused motion data capture and analysis plays a key role. Possibilities of using the known techniques and methods and their adaptation to a specific problem will be presented.

In the field of motion-patterns recognition, time-series analysis, clustering and other procedures useful in data mining and different statistical methods are of great importance. For fused-motion data procedures like Kalman filtering are useful.

The developed methods will be tested on simulated and then on actual measured data. By exploring application of various wireless sensors and procedures for fusion and analyzing motion data captured with these sensors, the expected contributions of the proposed science doctoral thesis also include recognition of specific selected complex-motion patterns.

Hybrid Reactive-Power Compensator

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Abtsract. The doctoral dissertation is about electric power quality, which is nowadays becoming an increasingly important factor. Until recently, the main requirements of the electricity consumers were reliable and sufficient power supply. With the liberalization of the electricity market, growing power consumption and the ever increasing number of modern electric devices present in all segments of our life (TV, personal computers, modern home appliances, controlled motor drives), the awareness of the importance of power quality is also growing.

The major responsibility in providing appropriate parameters of the quality of electricity is with modern compensation devices. The doctoral thesis will analyze the existing and propose new topological structures of the hybrid reactive-power compensator, where the improved economic efficiency and operational performance are the main objectives. In the main part of the dissertation, a control algorithm for the active part of the compensator will be presented. For the active part, the voltage-source converter (VSC) will be used with the capacitor connected on the dc-side. Besides, outlining the positive features of the proposed compensator, such as the low power ratings of the active part, ability to adapt to the changing conditions in the network, damping harmonic resonances and others, its drawbacks will also be presented and solutions will be given on how to avoid them.

Time-optimal current control of the static compensator

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Abstract. The topic of the doctoral thesis focuses on improved operation of the static compensator by using the developed advanced time-optimal current control algorithm. The algorithm - which belongs to the family of predictive control algorithms - optimizes operation of the static compensator thus achieving the fastest possible current responses by using discrete control systems.

The algorithm, which is based on a simplified mathematical model of the static compensator, can be used in accurate determination of the output quantities (control voltage). During fast changes in the reference current it predicts the current response, which is with the iterative algorithm optimized in order to achieve the shortest possible transition to a new stationary point. In practice, analytical derivation of the optimal solutions becomes complex and with standard digital-signal processors computationally-consuming, since the control algorithm considers the real output-voltage limitations of voltage source converter.

The presented optimization approach is designed for being used with a discrete-time system, while assuming certain simplifications to allow for fast and efficient optimization with no significant deviations from the theoretically optimal solution.

Operation of the current-control algorithm was compared with other similar control algorithms. One of its main advantageous is the evidently better dynamics by using the time-optimal current controller especially due to the developed optimization approach and utilization of the maximum capability of the converter.

Closed-loop noise reduction in transceiver systems operating in the UHF-frequency band

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Abstract. Research in the new RFID systems is most intense in the ultra-high frequency range (860MHz ~ 960MHz). The RFID systems have developed from discrete implementations to fully integrated solutions such as IDS circuit R902 and R1000 Impinj.

The cutting edge of development is focused on solutions that would allow the use of lower-quality components and antennas of reduced dimensions, since this is the only way to minimise the size and cost of the RFID systems. The reduced quality of components, notably the directional components that separate the transmit and receive path (directional couplers, circulators, transformers, etc.) and the antennas of small dimensions cause high levels of the transmitter-to-receiver leakage (self-jammer). The final result are difficult operation and an increased noise level of the receiver.

Reduction in the noise level caused by self-jamming and improvement in the receiver sensitivity are the main goal of the dissertation. The work is organized so that in Part One partial noise contributions are analyzed, with special emphasis laid on separation noise paths and effects of the amplitude and phase-noise components. The result will be a model of noise effects allowing fast assessment of the noise level in the received signal based on the known topology of the entire system and noise properties of individual components. In Part Two the possibility is explored of reducing the noise in the receiver caused by a high level self-jamming based on two methods. The first involves the use of a compensation signal employing an additional mixer circuit which shares the load stage with the main mixer. The second method enables cancellation of noise at a low frequency behind the mixer by identifying the amplitude noise component of the transmitting signal.

Recognition and usage of emotive parameters in recommender systems

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Abstract. The growing amount of multimedia content is making it hard for end users to find the relevant content. The goal of recommender systems is to assist the users by finding a small subset of relevant multimedia items for each user. Since each user has his/her own specific preferences, a recommender system must account for the individual differences when filtering the relevant content.

One way of improving the performance of recommender systems is to improve the underlying algorithms and the other is to use novel features that account for the unexplained variance in end users' preferences. The progress beyond the state of the art of the present thesis consists of introducing new parameters based on emotion and personality that explain a substantial part of variance of end users' preferences.

A recommender system is a model that uses input parameters (knowledge) to predict the user preferences (explicit user's ratings) and thus recommend content. The variance in the user preferences is not explained well enough with the parameters currently used in recommender systems. We contributed to the identification of important factors in recommender systems that extend the part of the explained variance by showing that emotions (attributes describing the users' emotive responses, e.g. valence, arousal etc.) and personality (attributes describing the users' personality, e.g. extraversion, neuroticism etc.) are parameters that account for a substantial part of the variance. As a consequence the success rate of the recommender system under observation has improved.

The presented thesis describes four novel scientific contributions: (i) a new content-based modelling approach based on affective metadata, (ii) a new personality-based user similarity measure for a collaborative filtering recommender, (iii) an emotion-detection algorithm that uses video recordings of users in spontaneous emotion expressions and (iv) a dataset that supports the first three contributions.

We built a dataset, named LDOS-PerAff-1, that features almost six hours of 52 subjects face video recordings with 70 different induced emotive states. The video sequences are annotated with big-five personality parameters of subjects and metadata related to the items. Furthermore, the dataset is freely available to the scientific community at the following address:

http://slavnik.fe.uni-lj.si/markot/Main/LDOS-PerAff-1

Our modelling of users with affective metadata in a content-based recommender system shows that applying the proposed solution brings significant improvement over generic metadata. We present a simple yet efficient method for modelling items and users through users' emotive responses in the valence-arousal-dominance space.

We present a novel user similarity measure which is based on users' personalities. The proposed personality-based user similarity measure yields significantly better results than the standard rating-based user similarity measure used in the state of the art recommenders under the new user conditions. The major limitation is the non-trivial acquisition of personality information because users find it annoying to fill-in extensive questionnaires and because it contains sensitive data that users are not necessarily willing to provide.

We present a methodology to be used in the detection of emotions from video sequences of users' faces. We evaluate the performance of the methodology on affective labelling on a dataset of posed face expressions and on a dataset of spontaneous face expressions. We use Gabor filtering-based low-level features, PCA for dimensionality reduction and the kNN classifier for affective labelling. The emotion-detection accuracy on the posed expressions dataset is 92% and on the spontaneous expressions dataset 62%.