ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization) Vol.2, Special Issue 1, March 2014

Proceedings of International Conference On Global Innovations In Computing Technology (ICGICT'14)

Organized by

Department Of CSE, JayaShriram Group Of Institutions, Tirupur, Tamilnadu, India on 6th & 7th March 2014

# Rank Preserving Discriminant Analysis for Human Behaviour Recognition Using Dash7 Protocol

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**ABSTRACT:** With the rapid development of the intelligent sensing and the prompt growing industrial safety demands, human behavior recognition has received a lot of attentions in industrial informatics. To deploy an utmost scalable, flexible, and robust human behavior recognition system, we need both innovative sensing electronics and suitable intelligence algorithms. In this paper, a new scheme for human behavior recognition on wireless sensor networks is proposed, namely Rank preserving discriminant analysis algorithm, which transmits the activities recognized from human or subject to network server. This activity signals are compressed by Hamming Compressed Sensing and the compressed signals are send to the network server. Heavy computations are performed by the network server and decompression also performed by network server. In the network server the classification process will takes place using nearest neighborhood algorithm. For transmitting of activity signals we are using Dash7 protocol which covers large area. Finally the results will be returned to the server. RPDA encodes local rank information of within-class samples and discriminative information of the between-class under the framework of Patch Alignment Framework. Experiments are conducted on the SCUT Naturalistic 3D Acceleration-based Activity (SCUT NAA) dataset and demonstrate the effectiveness of RPDA for human behavior recognition.

**Index Terms:** Human behavior recognition, wireless sensor networks, rank preserving, discriminant analysis.

## I. INTRODUCTION

Human behavior recognition is a complex issue, spans many disciplines and receives intensive attentions in industrial informatics. The basic steps involve sensing signal acquisition, information processing and pattern classification. The development of sensing electronics and intelligent algorithms results in innovations, efficiencies, and cost savings in many areas. In recent years, a dozen of effective methods have been proposed to automatically recognize human behavior and benefits the industrial informatics.

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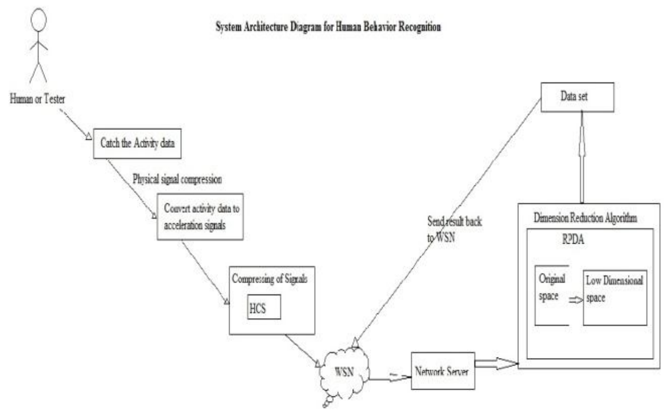


Fig.1. System architecture

A large scale WSNs, based on ZigBee protocol, is widely used in industrial monitoring. It is a low consumption device and has the capability to sense the variation information (e.g., temperature, pressure, and revolution speed) in a reliable way. WSNs based ZigBee protocol can be used in the application of human behavior recognition, because of the following reasons: 1) it has low power consumption, and thus we can control the size of body-worn sensing module, 2) the sensing modules build network flexibly and rapidly, since the protocol brings about the nature of self-organization and self-configuration, and 3) it has a relatively low cost of the sensing module. But when we compare ZigBee protocol with Dash7 Protocol, Dash7 protocol has several advantages. They can be listed as follows: 1) It (10m to 10km) Covers large area than ZigBee protocol (10m to 100m), 2) Less power consumption (<1 micro Watt) than ZigBee protocol (>1 micro Watt), 3) Higher penetration, 4) Lower latency and etc. So in our proposed system we are preferring Dash7 protocol.

In this paper, we introduce the rank order information to improve discriminant learning for human behavior recognition and present a new dimension reduction scheme termed Rank Preserving Discriminant Analysis (RPDA). Based on the above descriptions, precisely recognizing human behaviors captured by one 3D accelerometer becomes to be reality through the following steps: 1) utilizing HCS to compress the accelerometer signal, and then transmitting the compressed data to the network server via WSNs, 2) utilizing HCS to decode the compressed accelerometer signal in the network server, 3) training the RPDA projection matrix by using a small number of labeled samples, and 4) classifying the RPDA projected samples by using the nearest neighbor classifier, and 5) returning the recognition results to the wireless sensor.

The main contribution of this paper is to implement Dash7 protocol for human behavior recognition. Hamming compressed sensing (HCS) is a general information compression technique, which helps to reduce the time delay of transmission and is not tied to the algorithm RPDA. Given the limited page length, we will not be detailed the other parts which are easy to implement based on the references cited in this paper.

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## II. RELATED WORK

Dimension reduction algorithms can be simply grouped into two categories: unsupervised and supervised learning algorithms. In unsupervised learning, the class label information is unavailable. Principal Component Analysis (PCA) is the most representative unsupervised dimension reduction algorithm. It provides a roadmap for efficient relevant information extracting from the high-dimensional data space by reconstructing Gaussian distributed data through maximizing the trace of the total scatter. This simple, unsupervised and parametric method has helped the researches in various fields from neuroscience to computer vision, such as, image analysis, facial expression recognition and data compression, because of its simplicity.

Laplacian eigenmaps (LE) [5], which is a geometrically motivated algorithm, not only avoid the limitation of the number of projection vectors naturally, but also consider the nonlinearity of the data distribution. LE preserves the local geometry information in order to uncover the intrinsic geometrical structure of the original high-dimensional data by building a graph model which encodes the neighbourhood information. Therefore, LE is an efficient nonlinear dimension reduction method. Locality Preserving Projections (LPP) is the linear approximation of LE. Though LPP is a linear dimension reduction algorithm, it approximates the nonlinear problem properly by partially preserving the local geometry information.

In supervised learning, a training sample consists of an input instance and the associated class label. Linear Discriminant Analysis (LDA) [20] is the most representative supervised dimension reduction algorithm. It seeks to find a projection direction which minimizes the trace of the within-class scatter matrix and maximizes the trace of the between-class scatter matrix, simultaneously. In general, LDA performs excellently under the circumstances that different classes have an equal within-class scatter. Nevertheless, LDA suffers from the two main drawbacks: First, it is a globally linear dimension reduction algorithm and fails to discover the nonlinear structure hidden in the high-dimensional space. Second, to use LDA, small sample size (SSS) is a big problem. LDA needs a large number of training samples to acquire a good model. A dozen of algorithms have been proposed to deal with the SSS problem of LDA, such as PCA plus LDA [4] and direct LDA (DLDA). However, they fail to consider the local geometry of within-class samples and the discriminative information in selected subspace.

Although existing dimension reduction algorithms have been applied to human behavior recognition, there is still room to improve the classification precision. Recently, it has been observed that the Euclidean metric suffers from the concentration of measure phenomenon [16], since the difference of distances between pairs of high-dimensional samples are fairly indistinguishable. Extensive numerical experiments [15] verified the ranking of neighbors is important. Transferring distance information to rank orders benefits to recover the intrinsic data properties.

Non-matric multidimensional scaling (MDS) aims to preserve rank order information by matching distances among all data in the low-dimensional space with distances among all data in the original high-dimensional space. In addition, data-driven high-dimensional scaling (DD-HDS) was presented to improve the performance of the representation of high-dimensional data. Recently, Lespinats et al. proposed RankVisu to preserve small dissimilarities as possible, since small rank orders are more important.

In contrast to the classical spectral analysis based dimension reduction, we introduce rank order information to human behavior recognition and present a new dimension reduction algorithm, termed Rank Preserving Discriminant Analysis (RPDA). It differs from the aforementioned dimension reduction in considering the influence of rank order information in within-class and between-class. By introducing a penalized factor of distances that takes the concentration of measure phenomenon [16] into account, it preserves as much as possible the local rank order information of the within-class formed local patch. In addition, it is remarkable that the process of dimension reduction always companies variations in the original distribution. Therefore, we model the process which extracts the local discriminative information of the between-class by intentionally ignoring the rank order information. In order to understand RPDA, we fabricate the local rank information of

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within-class samples and the discriminative information of the between-class under the framework of patch alignment framework (PAF).

## III. RANK PRESERVING DISCRIMINANT ANALYSIS

In this section, we present a new supervised dimension reduction algorithm, Rank Preserving Discriminant Analysis (RPDA). The concentration of measure phenomenon [16] has significant impact on the performance of dimension reduction tools, because the differences of distances between pairs of high-dimensional samples are fairly indistinguishable [1]. A direct solution is to preserve the rank order information of within-class samples [15] in the process of transforming samples from the high-dimensional space to a low-dimensional subspace.
It is insufficient to consider only the rank order information, because the process of dimension reduction always companies variations in the original distribution [14]. Therefore, we design a discriminant information extracted way that ignores the between-class samples rank order information. This strategy is feasible for high-dimensional data to selectively shrink or stretch a suitable manifold. Similar to other spectral analysis abased dimension reduction algorithms, it can be built under Patch Alignment Framework (PAF), because PAF offers a platform to manipulate the local rank information of within-class samples and the discriminative information of the between-class samples. Under PAF, all these algorithms can be reasonably divided into part optimization and whole alignment two stages.

RPDA algorithm is described as follows:

Training set $X=[x_1, x_2, x_3,\ldots\ldots,x_N]€R^{D*N}$

**Input:** Class label $C_i € Z^n$
d: Dimension of the reduced space

**Output:** Orthogonal projection matrix $U= [u_1, u_2, u_3, \ldots.., u_d]€R^{D*d}$

**Step 1:** (optional) Use PCA projection matrix $U_{PCA}$ to reconstruct the original training set X;

**Step 2:** Part optimization: Construct N patches for the training set according to (1) and (2), and calculate the matrix $L_i$ for each patch using (5);

**Step 3:** Whole alignment: Sum of all patches in a global coordinate overall samples, and compute the whole alignment objective function (9);

**Step 4:** Compute the projection matrix $U_{RPDA}$ whose column vectors are the d eigenvectors of $XLX^T$ associated with d smallest eigen values.

**Step 5:** Return the final projection matrix $U= U_{PCA}U_{RPDA}$.

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## IV. DASH7 PROTOCOL

Dash7 is a low power long range wireless network technology based on the ISO 18000-7 Standard and uses a RF frequency of 433.92 MHz and a transfer rate up to 20 kbps. The range can be adjust from 100 to 10 kilometer with a dynamically adjustable data rate of 28 kbps to 200 kbps. The ISO Standard is not available for free. Dash7 (Developers Alliance for Standards Harmonization of ISO 18000-7) is a wireless technology created to have low power consumption and low latency response. Dash7 applies BLAST (Bursty, Light-data, Asynchronous, and Transitive) concept. Dash7 is based on ISO 1800-7 standard. Table 1 shows features of the Dash7 technology

Table.1. Dash 7 protocol

| | |
|---|---|
| Range | Dynamically adjustable from 10 meters to 10 kilometers |
| Power | Less than 1 milli watt power draw |
| Data Rate | Dynamically adjustable from 28kbps to 200kbps. |
| Frequency | 433.92 MHz (available worldwide) |
| Signal Propagation | Penetrates Walls, Concrete, Water |
| Real-Time Locating Precision | Within 4 meters |
| Latency | Configurable, but worst case is less than two seconds |
| P2P Messaging | Yes |
| IPv6 Support | Yes |
| Security | 128-bit AES, public key |

## V. CONCLUSION

In this paper, a new manifold learning based dimension reduction algorithm, Rank Preserving Discriminant Analysis (RPDA), was presented under the framework of patch alignment using Dash 7 protocol. Technically, rank orders do not encounter the concentration of measure phenomenon. Therefore, three type penalized factors were developed to encode the rank order information of the within-class samples. The between-class samples rank order information was ignored while the discriminative model of the between-class samples was constructed. Comparing to the classical unsupervised dimension reduction algorithms (e.g. PCA and LPP) and representative supervised dimension reduction algorithms (e.g. LDA and SLPP), RPDA has shown many competitive and attractive properties. In human behavior recognition for industrial informatics, RPDA is superior to the above algorithms in terms of recognition rate.

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By implementing Dash 7 protocol in this paper we can reduce the power consumption and can also be able to cover large area than the previous ZigBee protocol.

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