GESTURES RECOGNITION BY INERTIAL SENSORS USING KOHONEN NETWORK

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Man-machine interaction is ubiquitous in today's world. Despite the variety of ways how to organize this interaction, there are a lot of challenges to improve the control devices and methods of interactional data processing. The interaction must be as natural as possible for a human and it's the priority task in this research domain. One of the promising methods of the interaction is based on the human gestures, their recognition and interpretation.

System gesture recognition by inertial sensors. There are different gesture recognition approaches, which have been developed in recent years and can be categorized into two groups: optical and non-optical gestural recognition techniques.

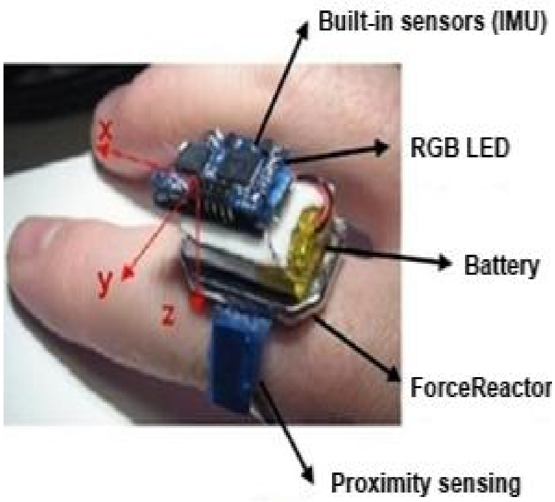


Figure 1. Pingu, smart finger ring for interaction by inertial sensors

In optical-based gesture recognition approaches, cameras are used as optical sensors. However, these approaches, which perform gesture recognition in some applications accurately, do not support applications that are required to work with no direct line of sight (occlusion problem). Furthermore, optical data is sensitive to illumination conditions and, therefore, can only be used under certain circumstances. Finally, the user should wear additional thing which must be comfortable and/or socially unacceptable. All these limitations are possible to redress by inertial sensors (IMU) [1].

The placing of such sensor was proposed by M. Roshandel and A. Munjal, who placed inertial system with sensors (4×4×0.9mm) on a finger ring [2]. This smart finger ring (Pingu) is presented on fig. 1. We use only IMU (MPU-6050) in our research by the same fixing method on index finger.

Gesture representation. The experimental data allows us to represent gestures in the XZ-plane because all our gestures imitate handwriting. We use 4 different gestures that draw the characters '0', '1', '2', '3'. Their trajectories are shown on fig. 2.

In our experiments, we present the trajectories of gestures as an image. According to M.K. Bhuyan and K. F. MacDorman [3] we have to make some steps of image training order to prepare an image for recognition. These steps are the following: 1-2) Two initial video frames; 3) edge image of the first frame; 4) difference image; 5) threshold difference image; 6) median filtering of threshold difference image, 7) thinning; 8) connected component labeling.

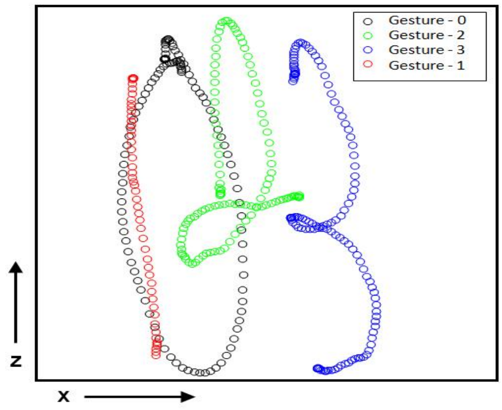


Figure 2. Trajectories of gestures on the XZ-plane

We represent gestures as the image matrix which consists of 0 or 1 (white or black), so we can just reduce the image to fixed size (it's necessary for the neural network learning). There is the reason to make the small image. In this case the image will contain only the monument points as the advantage in analysis and it will minimize time for neural network learning. So, we normalized all x-coordinates, increased them to the desired size and set them to an integer (1). After that, we repeated the same steps for z-coordinates.

$$X[i] = \text{round}\left(\frac{(sx-1)\cdot X[i]}{mx}\right); \tag{1}$$

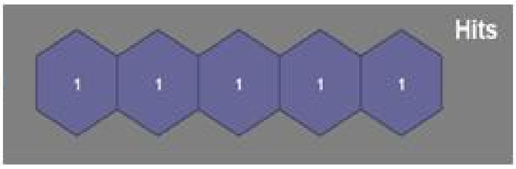
where *X[i]* is the coordinate X of the trajectory, *sx* is the width (X-axis) of the image [0, *sx*-1], *mx* is the maximum of the x-coordinate for normalizing.

Recognition by Self-Organizing Maps. We classified images of gesture trajectories using the Kohonen Neural Network (Self-Organizing Maps). We presented input data for Network as the matrix, where each matrix column is one image. Each column of the image follows previous column of this image in the column of input matrix.

In our tests we used 4 gestures and every image has the size [10×10]. The input matrix has the size [N,100], where N is numbers of patterns and 100 is 10*10 points of images. Our input matrix has to include not less one pattern of each gesture. We set size [4,1] for Kohonen map because we use only 4 different gestures.

Results and conclusions. As follows from the research, we obtained the map, where every part of the map has the same number of appropriate patterns with numbers of input data for learning (fig.3a). The tests showed that one pattern of each could be enough for recognition more than 90% examples (fig. 3b).

(a)



(b)

50 test for each	0	1	2	3
0	98%			2%
1	2%	92%	6%	
2		2%	96%	2%
3			2%	98%

Figure 3. Learning result of Kohonen map (a) and Table of test result (b)

The results show that our system provides gesture recognition. It uses for that minimum numbers patterns and minimal time (not more 3 seconds). Wearing of the sensor is an optimal and practical way because it's presented as the ring accessory. Actually, this system needs extension of the used gesture list and testing by more similar gestures between each other.

References

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Abstract

In this paper, a new wearable system to measure a gesture is described. It consists of a set of sensors (accelerometer and gyroscope) attached to the index finger, and of a microcontroller for index finger acceleration and angular velocity acquisition and conditioning. The paper focuses on the gesture recognition using the Kohonen neural network. The results show that the proposed system allows recognizing the basic gestures in aims to further implementation of the control device for man-machine gesture interaction.

Keywords: gesture, accelerometer, gyroscope, Kohonen network, image.

Анотація

У цій статті описана нова система для вимірювання жестів, що одягається. Вона складається з набору давачів (акселерометр і гіроскоп), прикріплених до вказівного пальця, і мікроконтролера для вимірювання прискорення і кутової швидкості вказівного пальця, їх приймання та обробки. У статті основна увага приділяється розпізнаванню жестів з використанням нейронної мережі Кохонена. Результати показують, що запропонована система дозволяє розпізнавати основні жести в цілях подальшої реалізації пристрою для людино-машинної взаємодії за допомогою жестів.

Ключові слова: жест, акселерометр, гіроскоп, мережа Кохонена, зображення.

Аннотация

В этой статье описана новая надеваемая система для измерения жестов. Она состоит из набора датчиков (акселерометр и гироскоп), прикрепленных к указательному пальцу, и микроконтроллера для измерения ускорения указательного палец и угловой скорости, их приема и обработки. В статье основное внимание уделяется распознаванию жестов с использованием нейронной сети Кохонена. Результаты показывают, что предлагаемая система позволяет распознавать основные жесты в целях дальнейшей реализации устройства управления для человеко-машинного взаимодействия с помощью жестов.

Ключевые слова: жест, акселерометр, гироскоп, сеть Кохонена, изображение.