method can reach 85.58% on the validation set and 85.00% on the testing set. On the other hand, the average accuracy of classification on skeletons extracted by ZSM and OPCA is higher than the average accuracy of classification on skeletons extracted by ZS and OPTA.

In addition, from the perspective of the classifiers, the accuracy of the classification of the decision tree and ensemble learning surpassed all the other classifiers. Based on the skeleton extracted by the MOPCA+DCEM+ATFM method, the decision tree and ensemble learning classifier can obtain 91.10% and 92.80% accuracy on the testing set, respectively. In contrast, the classification accuracy of other classifiers can only achieve about 85%. Although the ensemble learning classifier has a slight bit advantage over the decision tree regarding classification accuracy, the time spent on training the ensemble learning is much more than the decision tree.

In a word, for ten classes classification task, the best combination method is using MOPCA skeletonization to extract the skeleton, using ATFM and DCEM to offset the noise's influence, and using ensemble learning to predict the class of the static hand gesture. The overall accuracy can reach 91.1%, and the train time is 0.6134s.

## V. CONCLUSION

The hand gesture recognition based on the new image skeletonization methods, extracted gesture feature vector and using machine learning technique allow us to increase the classification accuracy. For 5 classes and 10 classes hand gesture classification task, the improvement of accuracy on test set is within the range of 0.4% to 20.4% , and that of 5% to 18% . The MOPCA+ADFM+DCEM method is effective in terms of average classification accuracy on test set. It achieves 97.5% on 5 classes recognition task and 85.00% on 10 classes recognition task. In addition, for 5 classes recognition task and 10 classed recognition task , the training time consumed by six classifiers is within the range of 0.7s to 8.9s and that of the 0.3s to 11s, respectively. It is set that ensemble learning model is the best classifier and it allows us to achieve 100% (5 classes) and 92.8% (10 classes) on test set. Increasing the accuracy of hand gesture classification based on the proposed skeletonization methods improves the technical characteristics of intelligent systems using video interfaces for entering commands and data, and makes a significant contribution to the development of semantic technologies for designing such systems.

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## Распознавание жестов рук на основе свойств скелетизированных изображений

Ма Ц., Цветков В. Ю., Борискевич А. А.

Распознавание жестов рук является важной задачей и может использоваться во многих практических приложениях. В интеллектуальных системах распознавание жестов рук может использоваться для ввода информации посредством видеоинтерфейса. В настоящее время распознавание жестов рук на основе скелета стало популярной темой исследований. Существующие методы имеют низкую дискриминационную способность из-за чувствительности признаков к шуму изображения. Мы предложили новые методы уменьшения влияния шума на выделение признаков изображения руки. Разработан новый метод распознавания жестов рук, основанный на свойствах скелетизированных изображений. Цель исследования состоит в повышении точности классификации жестов рук. Данный подход позволяет повысить точность классификации с 5% до 21% по сравнению с существующими известными методами.

Received 12.03.2023

# Automation of Educational Activities within the OSTIS Ecosystem

Alena Kazlova and Aliaksandr Halavaty
*Belarusian State University*
Minsk, Belarus
Email: kozlova@bsu.by,
alex.halavatyi@gmail.com

Natalia Grakova
*Belarusian State University of Informatics and Radioelectronics*
Minsk, Belarus
grakova@bsuir.by

***Abstract*—An analysis of the need for a comprehensive restructuring of the education system, taking into account the requirements of the digital economy, is presented. The ways of solving some problems of the implementation of the educational process at the level of general school education are determined. A semantic approach to building a complex of intelligent learning subsystems including teaching, assisting learning and analytical to accompany the learning process ones within the framework of the OSTIS ecosystem is proposed.**

***Keywords*—intelligent learning systems, semantics, OSTIS ecosystem, knowledge processing**

## I. INTRODUCTION

In the context of the transition to the information society and the comprehensive digitalization of all areas of human activity at its various levels, highly qualified personnel are of the greatest value. The volume and level of requirements for the presentation and use of information in all spheres of life is increasing, which entails the inevitable active involvement of professionals in the process of continuous education. A modern person in the information society must be able to adapt to rapidly changing information flows. The formation of such skills is the main task of every educational institution, including universities, which in modern conditions are subject to increasingly stringent requirements. This applies to both the level of teaching and the level of organization of educational activities. Today, the organization of educational activities in schools and in secondary specialized vocational, higher educational institutions largely determines the level of development of the state. Therefore, we can fully explain the great interest in the use of information technology in order to increase the efficiency of this activity. However, despite the rather active research carried out in this direction, it is too early to say that the use of information technology has significantly increased the effectiveness of educational activities. There are many reasons for this. Among them there are both objective technical, methodological reasons, as well as reasons of a purely organizational, administrative nature. These reasons include:

- lack of a systematic approach to the selection of the main objects and processes for automating the activities of educational institutions, including higher ones;
- a small number of viable technologies for the integrated development, implementation, operation, maintenance and evolution of educational automation tools;
- natural social resistance, conservatism that impedes the comprehensive automation of the educational process.

## II. CURRENT APPROACHES TO THE EDUCATIONAL ACTIVITIES AUTOMATION

Automation of educational activities requires an integrated approach, taking into account the peculiarities of educational work at all stages of education, from elementary school to graduation from the magistracy, and possibly further, when obtaining higher qualifications in graduate school. This approach certainly requires the use of existing ones, as well as further development and widespread use of methods and tools of artificial intelligence, and related disciplines. Work in this direction has been carried out by various groups of researchers for more than 30 years. Research is being carried out on the theory and methodology of distance education, new approaches to the development of distance and open education are proposed, based on the ideas of organizational design and reengineering of organizations, methods of knowledge engineering and the theory of agents, models of multi-agent systems and virtual organizations [1]–[7].

A number of authors identified and studied the main classes of systems and technologies needed to create virtual departments of universities and universities in general. Particular attention of researchers is paid to the problems of symbiosis of network and intelligent technologies, for example, models of intelligent learning systems based on multi-agent technologies [8], [9].

One of the current trends in the development of applied intelligent systems (IS) is the implementation of ISs that can not only solve problems from the relevant