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UDC 378

RESEARCH AND EDUCATION OPPORTUNITIES IN PARTNERSHIP BETWEEN HARARE INSTITUTE OF TECHNOLOGY AND BNTU

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Abstract. The current state of education and research and development (R&D) work in Harare Institute of Technology (HIT) is briefly reviewed, as well as opportunities in partnership between HIT and Belarussian National Technical University (BNTU). The proposed roadmap of cooperation between HIT and BNTU includes correspondence training of HIT teachers in the postgraduate program of the Belarusian National Technical University in English, organization of short advanced training courses in English for HIT teachers at BNTU, lecturing by BNTU teachers at HIT during short visits, implementation of joint R&D between the Innovation Hub of the Harare Institute of Technology and the BNTU Science and Technology Park "Polytechnic" and others.

Key words: education; research and development; scientific cooperation; postgraduate studies; educational programs.

ПЕРСПЕКТИВНЫЕ НАПРАВЛЕНИЯ СОТРУДНИЧЕСТВА ТЕХНОЛОГИЧЕСКОГО ИНСТИТУТА ХАРАРЕ И БНТУ В ОБЛАСТИ НАУКИ И ОБРАЗОВАНИЯ

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Аннотация. Кратко рассматривается текущее состояние образовательной и научно-исследовательской (НИОКР) работы в Технологическом институте Хараре (HIT), а также возможности партнерства HIT и Белорусского национального технического университета (БНТУ). Предлагается направления сотрудничества HIT и БНТУ включают заочную подготовку преподавателей HIT в аспирантуре Белорусского национального технического университета на английском языке, организацию краткосрочных курсов повышения квалификации на английском языке для преподавателей HIT в БНТУ, чтение лекций преподавателями БНТУ в HIT во время краткосрочных визитов, реализацию совместных НИОКР между Инновационным хабом HIT и Научно-технологическим парком БНТУ «Политехник» и др.

Ключевые слова: образование, научные и опытно-конструкторские работы, научное сотрудничество, аспирантура, образовательные программы.

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In April 2024, a representative of BNTU Andrey K. Tyavlovsky completed an internship at the Harare Institute of Technology (HIT), Republic of Zimbabwe. During the internship, a wide range of issues on possible cooperation between HIT and BNTU were discussed.

The main profiles of students training at HIT, provided by the relevant departments, are: biomedical technologies; chemical production technology (including food production technology); electronics, including programmable digital devices based on microcontrollers, industrial automation systems, power electronic devices; information technology; mechanics; metalworking technologies. Training is carried out at the first (bachelor's) and second (master's) levels of higher education on a fee-paying basis. The term of study in the bachelor's degree is 4 years, in the master's degree is 2 years. The schedule of the educational process in Zimbabwe is somewhat different from the schedule of the educational process in the Republic of Belarus: e.g., the academic year in Zimbabwe begins on August 5.

The Harare Institute of Technology has a sufficiently high scientific and technical level to develop cooperation with technical universities in Belarus, particulary with BNTU. It is also noticed that HIT has an urgent need to train highly qualified scientific personnel due to the lack of a system for training and certification of scientific personnel in Zimbabwe,

while the scientific and pedagogical level of the local teaching staff is sufficient for successful completion of postgraduate studies at BNTU in English. During the internship a round table was held with teachers of Biomedical Engineering and Electronics Engineering Departments who wish to improve their scientific qualifications in the postgraduate (PhD) program of BNTU. The round table discussed the issues of choosing a topic and a scientific supervisor, the structure of the dissertation research, confirmation of scientific and practical significance, testing the results of the dissertation research through publications in peer-reviewed scientific journals and presentations at international scientific and technical conferences, implementation of the results in production, the procedure for opposing and defending dissertations and other issues. Following the discussion, those present at the round table expressed great interest in completing postgraduate studies and defending dissertations in the Higher Attestation Commission of the Republic of Belarus, while during the conversation it became clear that a number of the teachers present already have a necessary scientific background and a completed or almost completed research, but experience difficulties with the publication of their scientific results due to the lack of peer-reviewed scientific journals on the relevant topic in the Republic of Zimbabwe and neighboring countries. So publications in Belarussian scientific journals and presentation of research papers on scientific and technical conferences in the Republic of Belarus could be a good way for Zimbabwean researches to approve their results and a possible point of cooperation for HIT and BNTU.

Scientific research and development (R&D) at the Harare Institute of Technology is conducted on applied topics within a separate structure – the Innovation Hub (Figure 1), which is a close analogue of the Scientific and Technological Park of BNTU "Polytechnic" in terms of its organizational principles and the tasks it solves. The Innovation Hub provides a laboratory base and equipment for scientific research, including such conducted as integral part of the educational process. If the R&D work turns into start-up, the Innovation Hub provides advertising and information support, and, in case of a start-up's success, provides further support in registering spin-off company. Part of the research work is provided by budget funding from the Ministry of Education and Science of the Republic of Zimbabwe while the main funds come from the implementation of business contracts with enterprises and organizations in Zimbabwe.

The main areas of scientific research in the Innovation Hub are related to solutions to issues of import substitution of various electrical and electronic equipment, in particular, power transformers, industrial automation systems based on programmable logic controllers, mobile payment terminals, validators for public transport; development and production of injection molds for plastics under direct business contracts, as well as production of plastic parts themselves using high-pressure molding; development of new chemical production technologies; development of mobile water purification and disinfection systems; production of household chemicals as part of a startup; production of bottled water and soft drinks on behalf of the spin-off company Instifoods, etc.

Figure 1 – The Innovation Hub

Figure 2 – Inside the workshop

The Innovation Hub has a significant machine park located in two workshops on the campus. One of them contains CNC machines, machining centers, a casting machine, etc., used in contract work and scientific research (Figure 2). The other workshop contains manually controlled machines. These machines are used mainly for training students as part of industrial practice, which helps students better understand the principles of operation of the equipment, its modes, and metalworking technologies. Thus, the Innovation Hub also acts as a base for industrial practice, which at the Harare Institute of Technology is carried out on the institute's own premises without sending students to third-party organizations.

The Harare Institute of Technology demonstrated a high interest in cooperation with BNTU in the educational and scientific spheres. As specific proposals for cooperation in a course of mentioned internship, the representatives of the Institute named the implementation of joint educational programs at the first stage of higher education according to the "2 + 2" scheme, training of students of the Harare Institute of Technology at the BNTU Summer School in English, full-time education of master's students at the second stage of higher education at BNTU in English, correspondence training of teachers of the Harare Institute of Technology in the postgraduate program of the Belarusian National Technical University in English, organization of short advanced training courses in

English for teachers of the Harare Institute of Technology at BNTU, lecturing by BNTU teachers at the Harare Institute of Technology during short visits, implementation of joint R&D between the Innovation Hub of the Harare Institute of Technology and the BNTU Science and Technology Park "Polytechnic". The main interest from the Zimbabwean side is caused by the specialties of biomedical directions, which corresponds to the profile of the Department of Design and Production of Devices of the Instrument Engineering Faculty of BNTU. On these issues, it seems appropriate to conclude Cooperation Agreements between the relevant divisions of BNTU and the Harare Institute of Technology.

UDC 621

SCALABLE 3D PERCEPTION: FROM ENVIRONMENTAL RECONSTRUCTION TO WORKPIECE MEASUREMENT

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Annotation. Three-dimensional geometric perception serves as a primary means for understanding the environment and objects, essential for both industrial and everyday applications. Advances in sensor technology and algorithms have expanded the scope of 3D perception, enabling its use across various fields such as geological surveying, robotic navigation, and industrial manufacturing. However, the practical application of raw point clouds, which consist of discrete 3D points, faces challenges related to robustness and accuracy, especially when derived from diverse sensors with differing characteristics. This paper introduces the "Point Cloud +" approach, incorporating multi-modal sensor fusion, deep feature extraction, active viewpoint planning, and motion priors. The approach enhances raw point clouds with additional features and priors, supporting robust and precise perception for both large-scale environmental reconstruction and workpiece measurement. Key contributions include a geometric-semantic joint mapping framework for outdoor environments, a degeneration-aware place recognition method, and a planning-control-reconstruction system for accurate workpiece measurement.

Keywords: 3D perception, point clouds, multi-modal sensor fusion, environmental reconstruction, workpiece measurement, deep feature extraction, viewpoint planning, accuracy

МАСШТАБИРУЕМОЕ 3D-ВОСПРИЯТИЕ: ОТ РЕКОНСТРУКЦИИ ОКРУЖАЮЩЕЙ СРЕДЫ ДО ИЗМЕРЕНИЯ ЗАГОТОВОК

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Аннотация. Трехмерное геометрическое восприятие является основным способом понимания окружающей среды и объектов, что играет ключевую роль как в промышленности, так и в повседневной жизни. Прогресс в области сенсорных технологий и алгоритмов обработки расширил возможности 3D-восприятия, позволив его применение в таких сферах, как геологические исследования, навигация роботов и промышленное производство. Тем не менее, использование необработанных облаков точек, представляющих собой дискретные трёхмерные точки, сталкивается с проблемами устойчивости и точности, особенно при использовании различных сенсоров с разными характеристиками. В данной работе представлен подход «Point Cloud +», включающий многомодальную сенсорную интеграцию, глубокое извлечение признаков, планирование точек обзора и учёт движения. Этот подход добавляет к исходным облакам точек дополнительные признаки и приоритеты, улучшая их устойчивость и точность в задачах как крупномасштабной реконструкции окружающей среды, так и точного измерения заготовок. Основные элементы включают геометрически-семантическую карту для неструктурированных открытых пространств, метод распознавания местности с учётом деградации данных, а также систему управления и реконструкции для точного измерения объектов.

Ключевые слова: 3D-восприятие, облака точек, многомодальная сенсорная интеграция, реконструкция окружающей среды, измерение заготовок, извлечение признаков, планирование точек обзора, точность.

Three-dimensional geometric perception is humanity's most common and fundamental means of understanding the surrounding environment and objects, playing a crucial role in both production and daily life. Recent advancements in sensor hardware and processing algorithms have significantly accelerated the development and application of 3D perception techniques. From geological surveys to robotic navigation and industrial manufacturing, point clouds are widely used to represent environments or products across varying scales. However, challenges remain in the real-world application of raw point clouds at all scales.

Raw point clouds are, by nature, discrete sets of homogeneous 3D points with positional coordinates as their primary attributes. Only through the arrangement and proximity of these points can geometric insights into objects, environments, or surfaces be discerned. Furthermore, point clouds captured from different hardware (e.g., 2D LiDAR, 3D LiDAR, laser scanners) exhibit variations in perceptual range, field of view