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HARNESSING THE POWER OF ARDUINO SIMULATORS FOR EFFECTIVE IOT EDUCATION

Purpose. The Internet of Things (IoT) is changing the way we interact with the world around us. By connecting the devices and systems around us through the Internet, this technology is driving innovation in a multitude of industries. It increases the demand for professionals with knowledge and skills in IoT systems and technologies. To meet this demand, educational institutions are increasingly incorporating IoT-focused curricula and hands-on training for information technology professionals. This paper aims to explore the role of Arduino simulators in IoT training, especially in distance learning, and to comprehensively analyze the functionality and benefits of these virtual tools.

Research methods. A combination of literature review and analysis of popular Arduino simulators, by studying their advantages and disadvantages in the context of IoT learning.

Scientific novelty. An in-depth examination of the advantages of Arduino simulators as a powerful tool for teaching IoT in a distance learning environment. Providing a comprehensive analysis of their functionality and integration strategies, the importance of these virtual platforms in IoT education is justified.

Practical significance. The benefits of Arduino simulators are to demonstrate IoT education in distance learning environments. The analysis can contribute to developing effective strategies for using these virtual tools in IoT education. The potential of Arduino simulators for facilitating access to quality education and training of skilled professionals in the field of information technology is also highlighted.

Results. The study demonstrates the effectiveness of Arduino simulators in improving the quality of IoT education in distance learning. Through a detailed analysis of their functionality and benefits, the paper demonstrates the potential of these virtual platforms in developing interactive and dynamic learning experiences. The study highlights the applicability of Arduino simulators for facilitating teacher-student interaction, enhancing collaborative project development and experience sharing, and facilitating assessment of learning achievements.

Key words: Arduino simulators, IoT education, virtual platforms, pedagogical strategies, distance learning, blended learning.

The problem and its connection with scientific and practical tasks. The Internet of Things (IoT) is rapidly evolving and becoming an integral part of modern society, with its ubiquitous presence in industries such as healthcare, agriculture, smart cities, and Industry 4.0. This technology connects the devices and systems around us to the Internet allowing real-time data collection, analysis, and decision-making [1,2].

IoT education faces many challenges, especially implementing distance learning programs. Traditional teaching methods have often been based on hands-on activities with physical equipment, which are difficult to replicate in remote environments. In addition, the dynamic and interdisciplinary nature of the IoT requires teachers to use innovative approaches to convey complex concepts and develop practical skills in students.

Arduino simulators have become a powerful solution to these challenges, offering a virtual environment that exactly mimics the functionality of physical Arduino boards. These simulators allow students to learn, practice, and experiment with programming and electronics, even in remote environments, and provide instructors with versatile tools to create engaging and interactive learning experiences.

Analysis of the recent research. Research in IoT education shows that Arduino is becoming an increasingly popular and widely used platform for learning programming and electronics [3-5]. This electronic platform allows students to learn programming and electronics by creating interactive projects, providing hands-on experience with basic IoT concepts such as sensors, actuators, communication protocols, and data analysis. As a convenient and versatile tool, Arduino plays an important role in preparing students for an IoT-based future [6-9].

Setting the task. The objectives of the study are to analyze the effectiveness of Arduino simulators when used in distance learning to improve students' learning of IoT concepts, as well as the advantages and challenges of their use in the educational process.

Research material and results. Arduino simulators have become an innovative solution for IoT training, especially in distance learning environments where access to physical equipment may be limited. These virtual platforms offer detailed emulation of Arduino boards, allowing students to learn programming and electronics concepts in a safe and controlled environment.

Based on the Arduino project, an open-source hardware and software system aimed at simplifying electronic project development, Arduino simulators were developed and evolved along with the growing interest in the IoT field. As the demand for affordable and cost-effective training tools grew, software developers introduced simulators that accurately reproduce the behavior of Arduino boards in a virtual environment [10]. These include the web-based simulators Wokwi [11], Tinkercad Circuits [12], and simulators in the form of desktop applications - Fritzing [13] and SimulIDE [14].

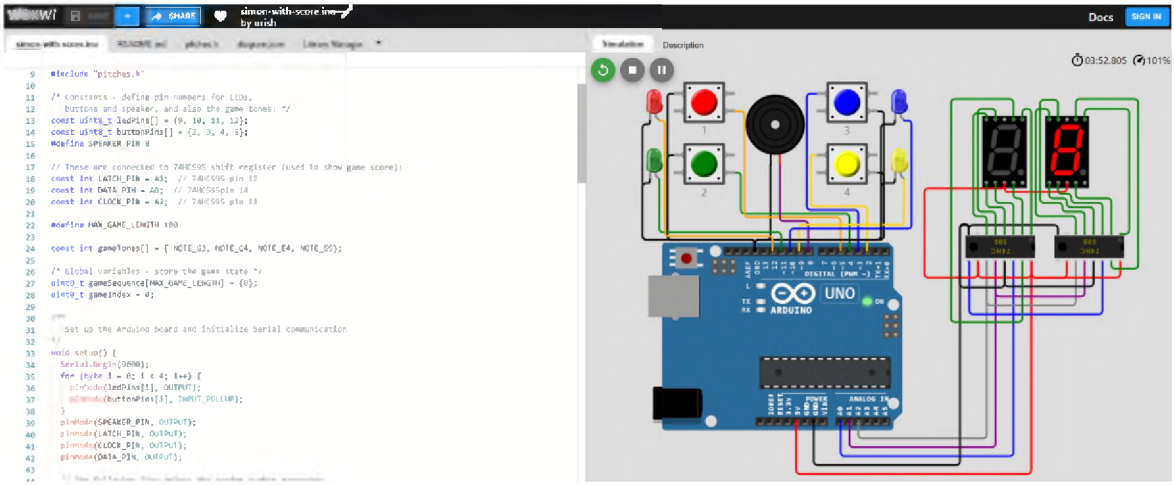

Fig. 1. The appearance of the Wokwi Web Simulator with the downloaded project [15]

These simulators include a range of features designed for novice and experienced users, offering a versatile learning experience for students with varying levels of familiarity with electronics and programming. They typically provide:

Realistic emulation: simulators aim to provide an authentic Arduino experience by emulating the behavior of genuine physical boards. This accurate replication allows students to test and verify their code, providing valuable insight into the real-world performance of their projects;

Integrated Development Environment (IDE): many Arduino simulators are equipped with an integrated development environment that allows users to write, compile, and download code to the virtual board. This feature greatly simplifies the learning process by offering a single platform for both software development and hardware emulation;

Component libraries: for simulating a wide range of electronic projects, Arduino simulators offer extensive libraries of virtual components, including sensors, actuators, and display modules. These extensive libraries allow students to explore different aspects of IoT systems and experiment with a variety of configurations;

Cross-platform: many Arduino simulators are presented as web applications, allowing them to be used on different operating systems. It also means there are no significant hardware requirements for using these tools.

Arduino simulators have many advantages. These virtual tools provide an affordable, efficient, and cost-effective alternative to physical equipment, making it easier for educators to teach IoT concepts and promote the development of practical skills in students. Among these benefits are:

Accessibility: By eliminating the need for physical hardware, Arduino simulators make IoT learning more accessible and inclusive. Students who do not have the means to purchase Arduino boards and components can learn programming and electronics using these virtual platforms;

Cost-effective: Arduino simulators provide a cost-effective solution for IoT education by reducing the costs associated with purchasing, maintaining, and upgrading physical equipment. This financial advantage allows educational institutions to allocate resources in better way and invest in other aspects of the curriculum;

Safety: Working with electronics and hardware components can be risky, especially for inexperienced students who may accidentally damage equipment or injure themselves. Arduino simulators provide a safe learning environment in which students can experiment with programming and electronics without the risk of damaging equipment or injuring themselves;

Instant feedback: Arduino simulators allow students to receive immediate feedback on their code and circuits. This instant feedback allows them to identify errors and troubleshoot more effectively, leading to a deeper understanding of basic concepts and promoting the development of problem-solving skills;

Scalability and flexibility: With extensive component libraries and the ability to emulate multiple Arduino boards, simulators provide a scalable and flexible learning platform that can adapt to different educational needs. Teachers can design lesson plans and assignments to suit different training levels and learning objectives, ensuring student engagement and interest throughout the course.

With distance learning becoming an everyday reality in our education, the necessity of including Arduino simulators in distance IoT courses is essential. It allows a blended learning approach, enhances students' ability to work collaboratively on projects, provides an interactive assessment of students during their work, and allows for iterative project development.

The challenge in using simulators in learning IoT can be the lack of physical interaction with Arduino electronic boards and components. In addition, simulators may have limited support for some hardware components and sensors. Teachers should consider these difficulties when designing appropriate training courses. At the same time, the benefits of using Arduino simulators to teach IoT principles outweigh the challenges, especially in a distance learning context.

Conclusions and directions for further research. The Internet of Things has quickly become a crucial field for a variety of industries as well as for everyday use. As a result, the necessity for effective IoT training has become paramount, especially in distance learning environments, where traditional teaching methods can become ineffective. Arduino simulators have proven to be an effective solution to the challenges faced by teachers and students alike, offering an affordable, cost-effective, and fun platform for learning programming and electronics.

The analysis of the use of Arduino simulators in IoT training allows us to move on to developing strategies for incorporating these virtual tools into the distance learning environment and using their potential to create interactive and dynamic learning experiences.

Developments in technology provide many opportunities for further research and development in introducing Arduino simulators into IoT education, which are versatile and powerful resources for teachers and students alike. By using the capabilities of these tools, it is possible to create an environment in which access to quality IoT education has been enhanced, learning efficiency is improved, and new information technology professionals have been trained.

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ДОСЛІДЖЕННЯ ВПЛИВУ РЕЖИМІВ ОБТИСНЕННЯ НА ВИТРАТИ ЕНЕРГІЇ ПРИ ХОЛОДНОМУ ПРОКАТУВАННІ ТОНКИХ ЛИСТІВ

Мета: дослідити процес холодного прокатування тонких сталевих листів за допомогою інженерної програми DEFORM 3D для визначення енергосилових параметрів обробки та встановити раціональні режими прокатування для підвищення енергоефективності процесу обтиснення.

Методи дослідження: для дослідження процесів, що відбуваються при виготовленні тонкого листа зі сталевого матеріалу методом холодного прокатування, було виконано моделювання з використанням комп'ютерної програми DEFORM 3D, яка дозволяє точно визначити технологію холодного прокатування та витрати енергії на процес. Під час моделювання було створено модель процесу холодної обробки тонкого листа; задані початкові дані, режими обтиснення і температура обробки, параметри руху прокатних валків та оброблюваної смуги, коефіцієнт тертя; обрано матеріал заготовки і встановлено його властивості. Визначено тип об'єктів моделювання, де встановлено, що інструмент має жорсткий тип, а оброблюваний матеріал – пластичний. Головним призначено верхній прокатний валок. При моделюванні процесу холодного прокатування листового матеріалу використовувався аналіз Лагранжа. Було визначено кількість кроків моделювання, яка дорівнювала 100. Обробка відбувалася у системі SI.

Наукова новизна: вперше отримані аналітичні залежності для визначення енергосилових параметрів холодного прокатування тонких сталевих листів за допомогою моделювання процесу методом дискретних елементів

Практична значимість: визначено раціональні режими обробки металу для удосконалення технологічного процесу холодного прокатування тонких листів.

Результати. Виконано дослідження процесу пластичної деформації матеріалу за криволінійною сіткою, визначено поле векторних переміщень і встановлено, що максимальне переміщення сталевого матеріалу здійснюється під дією верхнього прокатного валка, досліджено розподіл напружено-деформованого стану оброблюваного матеріалу і визначено максимальні напруження в зоні деформації. Вивчено розподіл зусиль прокатування і крутного моменту, що дозволило визначити їхні максимальні значення, які спостерігаються на 7-9 секунді обробки. В подальшому величина цих показників зменшується через зникнення захоплюваних сил і встановлюється сталий процес холодного прокатування.

Ключові слова: моделювання, осередок деформації, прокатний валок, тонкий лист, холодна прокатка, витрати енергії, комп'ютерна програма

Проблема та її зв'язок з науковими та практичними завданнями. У металургійній промисловості для отримання тонких листів широко використовуються технології прокатування в холодному стані. Такий технологічний процес дозволяє отримати листові вироби точного роз-