THE ROLE OF VIRTUAL SIMULATORS IN LEARNING AND DEVELOPING ARDUINO-BASED ELECTRONIC SYSTEMS

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Annotation: *This article analyzes various virtual simulators used for learning and working with Arduino and other microcontrollers. Simulators help beginners understand programming concepts and the functioning of electronic components, while also enabling advanced users to develop and test more complex projects. The paper discusses platforms such as the Virtronics Arduino Simulator, Arduino Pins, Virtual Breadboard, and others, highlighting their advantages and limitations.*

Keywords: *Arduino, microcontroller, simulator, electronic projects, Virtual Breadboard, Arduino Pins, Virtronics, code testing.*

The programs mentioned above play a crucial role in the early stages of learning, helping users grasp the fundamental principles of microprocessor operation and understand how to program them effectively. However, to truly observe and analyze the outcomes of one's work, it is often necessary to have access to a physical Arduino board along with various electronic and robotic components.

Although purchasing hardware is relatively straightforward, some individuals may prefer not to wait for online orders to arrive or may lack immediate access to the required components. For such users, numerous Arduino simulators have been developed, offering virtual environments equipped with a wide range of microcontroller elements and circuit components. One such tool is the "Virtual Library for Arduino", an educational platform designed to guide beginners through their first steps in the world of electronics using Arduino chips. While it includes fewer components compared to the full "Virtual Breadboard" software, it provides an excellent environment for understanding Arduino commands and their real-time effects. As users advance, it is recommended that they transition to the full version of "Virtual Breadboard" integrated with the "Arduino Toolkit plugin", which offers expanded functionality, advanced debugging options, and more complex simulation capabilities.

The Arduino Simulator by Virtronics is widely regarded as one of the most comprehensive and functional tools available today for Arduino programming and circuit emulation. Its primary advantage lies in its extensive feature set, which enables users to test, verify, and debug their sketches efficiently. In addition to code validation, the simulator allows users to visualize the internal processes of the sketch, providing detailed insights into how the program interacts with various components in real time.

This makes the Virtronics Arduino Simulator particularly valuable for experienced users and developers who aim to refine and expand their projects with greater precision. By offering both a practical and visual approach to debugging, it bridges the gap between theoretical programming and hands-on hardware experimentation, serving as an essential educational and prototyping tool for embedded system design [1].

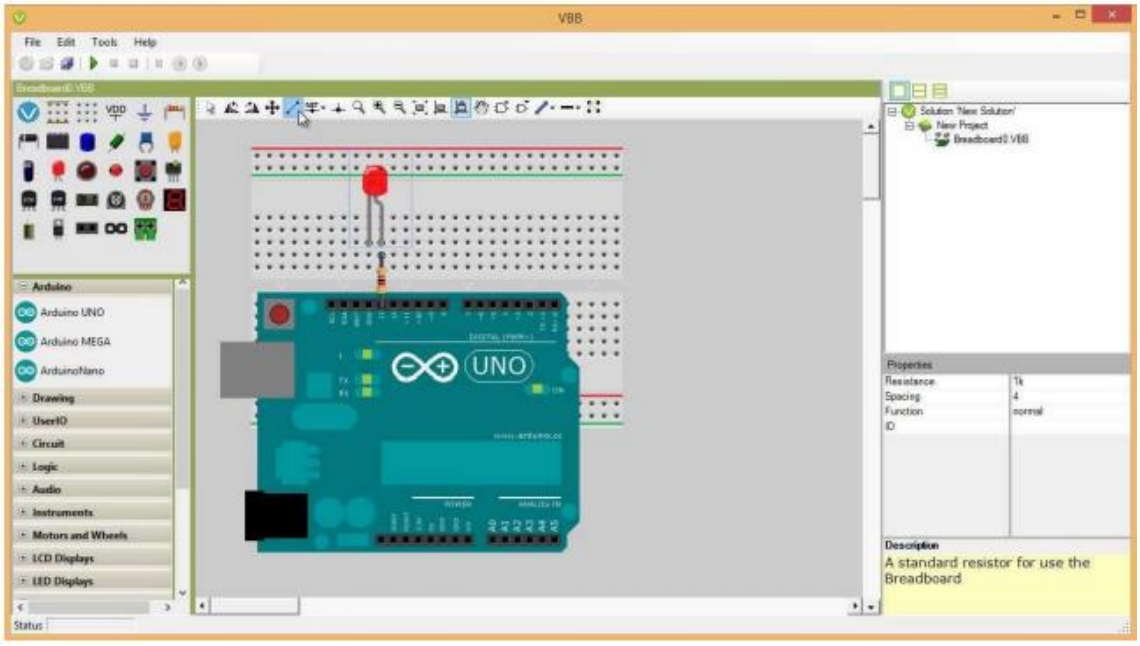

Fig.1. Virtual simulator interface for Arduino

Arduino Pins is an online simulation platform designed for developing electronic projects using Arduino, Raspberry Pi, and similar embedded systems. The environment allows users to create virtual circuit connections intuitively by dragging and dropping components onto the workspace and connecting them through virtual "wires".

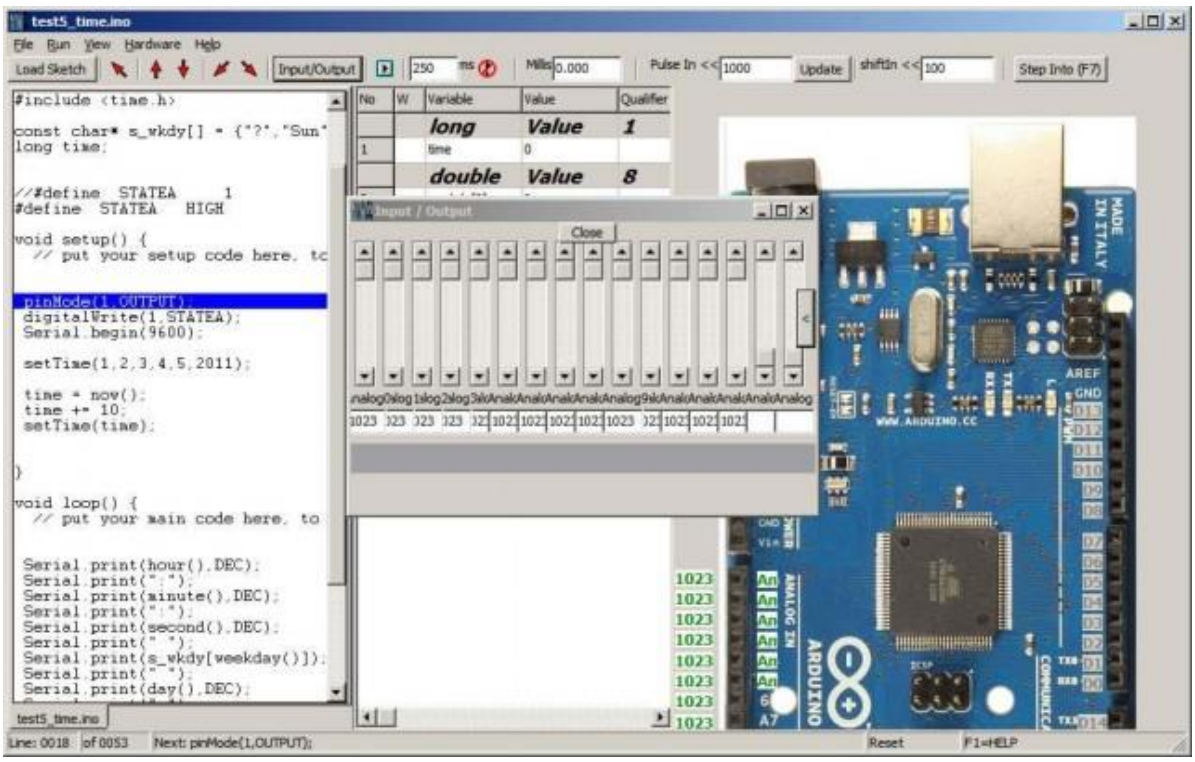

Fig.2. Interface simulator for Arduino (according to Virtronics)

This approach provides a hands-on experience that closely resembles assembling real hardware. Although the component library is relatively limited-containing only the essential models suitable for beginners-it remains an excellent tool for introductory experimentation and learning the basics of circuit design. For more advanced users, the platform offers a flexible component editor, which allows the addition of new radio or electronic components required for complex projects.

Furthermore, users can write and execute code directly within the simulator using the built-in programming environment, which supports standard Arduino syntax. However, since all simulation processes occur online, a stable internet connection is necessary to run and visualize the project effectively [2, 3].

Many developers prefer to simulate their projects within virtual environments, even when working alongside the physical placement of microcontrollers and other hardware components. Notably, some online platforms support the integration of physical devices, allowing users to combine simulation with real-world testing.

This hybrid approach enables developers to leverage extensive extensions for sensors, actuators, and other components, significantly enhancing the scope and accuracy of simulations.

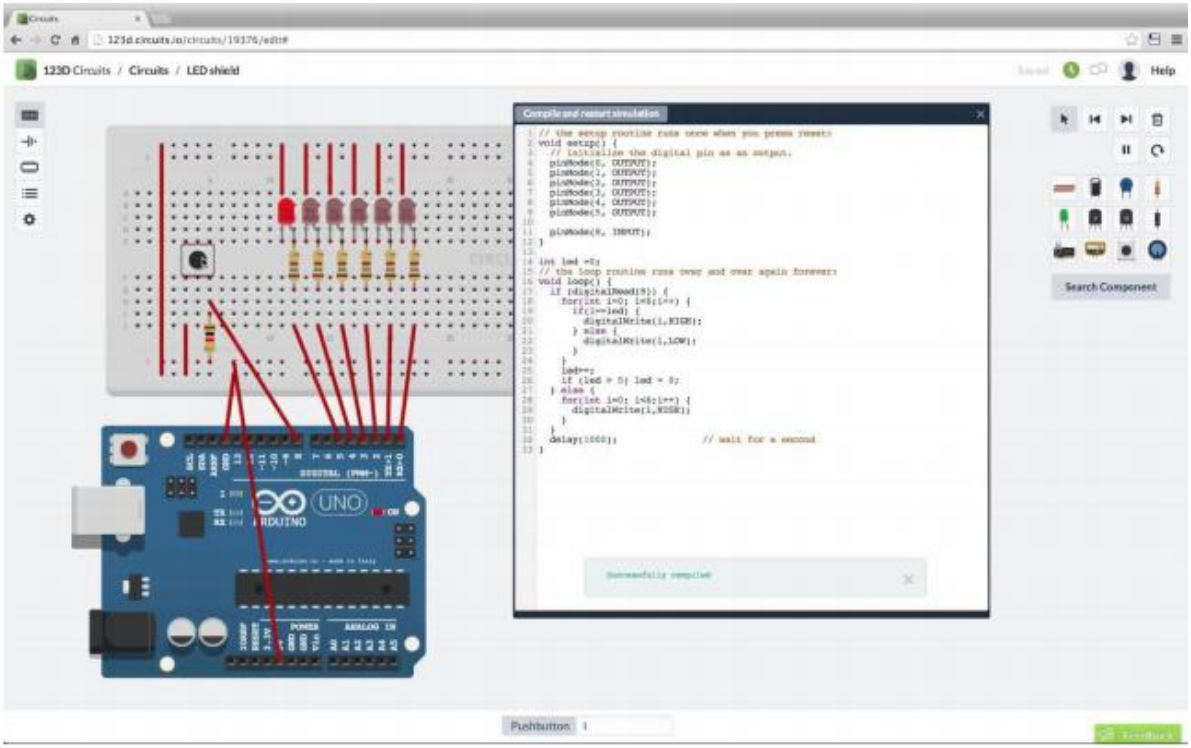

Fig.3. – Arduino pins interface

Virtual simulators are generally designed to be user-friendly and illustrative, featuring a layout where the left panel displays animated visualizations of circuit behavior, while the right panel provides a block-based programming interface. Certain output commands can demonstrate results even without the connection of physical components, such as Arduino boards or audio devices, making it easier to test and debug code in advance [4, 5].

To further support practical implementation, many platforms allow users to generate and print detailed schematics of the electronic connections, facilitating smoother transition from simulation to physical assembly. This combination of visualization, code execution, and schematic generation makes virtual simulators an invaluable tool for both educational purposes and project prototyping.

Conclusion: Virtual simulators significantly simplify the process of learning microcontroller programming and testing projects. They allow users to test code, visualize component behavior, and prepare electronic schematics. Consequently, simulators serve as an essential tool not only in educational settings but also in the development of complex electronic projects.

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