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Electronic Circuit Simulation Software

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Abstract: A simulation is an imitation of the operation of a real-world process or system. The act of simulating something first requires a model to be developed; this model represents the key characteristics, behaviours and functions of the selected physical or abstract system. Simulators can be used as an effective means for teaching or demonstrating concepts to students. Electronic circuit simulation uses mathematical models to replicate the behaviour of an actual electronic device or circuit. Simulating a circuit's behaviour in 3D before actually building it can greatly improve design efficiency and providing insight into the behaviour of electronics circuit designs. Through the use of a simulator, the user may investigate the relative superiority of each design without actually fabricating the circuits themselves. After carefully analysing the 3D simulation of the circuit, the user can understand the ramifications of each design, and the best circuit may then be fabricated.
Keywords*: Electronic Circuit Simulation, Unreal Engine 4, von Neumann architecture, Doubly linked list, Finite State Automata

I. INTRODUCTION

Simulation is the imitation of a real environment. It is software program that allows the user to observe an operation virtually, without actually performing that operation. Being free from the disasters that take place during training sessions with circuits/electronic devices, a simulation software looks upon all physical limitations. Simulation is used in many contexts, such as simulation of technology for performance optimisation, safety engineering, testing, training, education, and video games. Formally, we can define simulation as: "the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behaviour of the system of or evaluating various strategies (within the limits imposed by a criterion or a set of criteria) for the operation of the system". Simulators can be used to simulate any electronic circuit. The main drawback of practical experiments on Electronic circuits is that the user cannot see the flow of current, voltages at a specified point, etc. Our model tries to eradicate all these problems by providing a 3D representation of the circuit and also provides a way for showing how the current moves. Unfortunately, the design and implementation of simulators is almost as complex as the systems or circuits being simulated. Our model is easy to maintain and extend while at the same time preserving its relative efficiency.

A. Aim

Designing a 3D Electronic Circuit simulator using Unreal Engine 4 to provide a comprehensive way for the users to understand the basic concepts of electronic circuits and von Neumann architecture.

B. Objective

The primary objective is to develop a 3D simulation of electronic circuits that is interactive and real time, so that students easily understand the basic theory of circuits. To attain this successfully, the system must meet the following goals:

1) To provide 3D visualized simulation of electronic circuits.
2) To build an Interactive, vivid and intuitive.
3) Easy understanding of the basic theory of circuits.

II. DESIGN

We propose to implement this system using a custom Linked list approach. Since a 3D world has 3 coordinates, it is difficult to represent Circuit Elements using the standard von Neumann Matrix method. A custom linked list, which a derived from doubly linked list [4][5] has two parts:

A. Forward Array
B. Backward Array

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Each array contains references to the parent object files of the elements in the system. This helps to call each functional element to return its properties. The forward array, can only contain a single Reference to the forward element. [3] While the backward array keeps tracks of all the previous connected elements. This optimizes the process of checking the connection completion by reducing the check to a single element rather than all the connected elements.

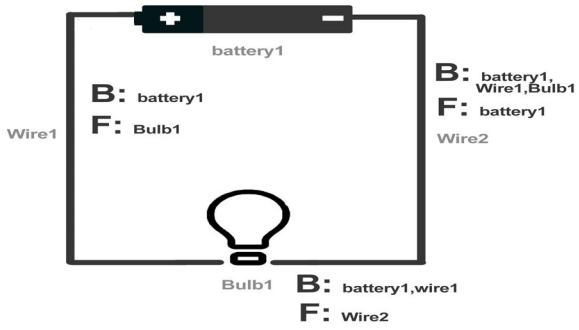


Fig. 1.1. Representation of basic circuit using custom linked lists

1) Assuming The Components Are Connected Anti-Clockwise, The Back Array Of Each Component Changes As

a) WIRE1 is connected: The Previous component, i.e. the battery reference is added to the back array of Wire1.

b) BULB1 is connected: The forward array of Wire1 is set to the Bulb1 reference. The back array of Wire1 is copied to the back array of Bulb1, and then wire1 is added to the back array of Bulb1. This results in the back array of Bulb1 having 2 components, battery1 and Wire1.

c) WIRE2 is connected: The forward array of Bulb1 is set to Wire2 reference. The back array of Bulb1 is copied to the back array of Wire2, and then Bulb1 is added to that back array. This gives the back array of Bulb1: Battery1, Wire1 and Bulb.

d) WIRE2 is connected to Battery: The Battery checks the back array of the component connected to it, in this case WIRE2. If it (Battery1) finds its own reference in the first slot of back array, the circuit is completed.

e) The Battery will then acquire the resistances of all the components in the circuit and calculate the current using OHM's law. [1][2]

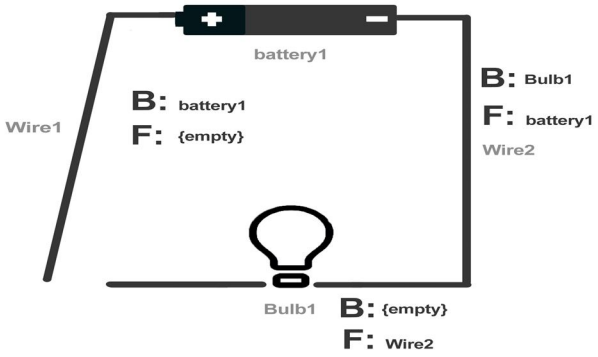


Fig. 1.2. Representation of changes in array after disconnection of an element

2) Disconnection of Wire1

a) End of Wire1 is disconnected from the bulb. The Wire1 calls its element in the forward array i.e. Bulb1 and tells it to empty its back array. The forward array of the Wire1 is cleared after this step.

b) Bulb1 calls the element in its forward array i.e. Wire2 and overwrites the Wire2's back array with its own (Bulb1). Bulb1 object reference is then added to Wire's back array, making the back array as: Bulb1

c) Wire 2 calls the element in its forward array i.e. Battery1 to check the circuit completion.

d) Since Battery1 can't find its 'self' reference in the Wire2's back array, it concludes the circuit is Open.Thus no current flows.

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III. WORKING

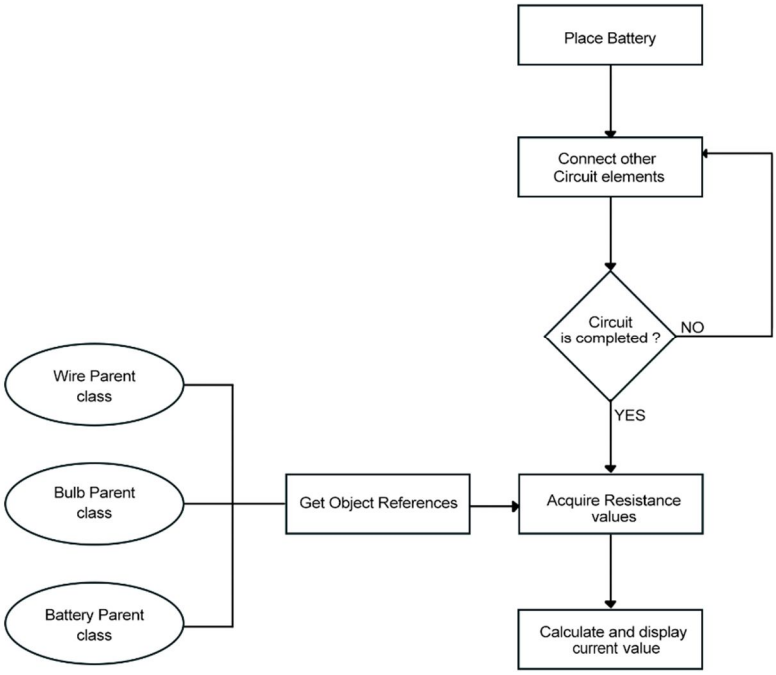


Fig. 2. Working model of Simulator

The user selects the Battery component from the UI and places it in the simulator canvas. After the battery is placed the simulator registers it as a unique component. The user then selects and connects the desired components from the UI. Each component is registered with the simulator as a unique and independent component. After the circuit is completed i.e. the positive and negative sides of the battery is connected together, the battery calls each unique object it is connected to and accesses their info. The resistance of each component is used to calculate the current using Ohms Law. [1] This process happens every 0.1 secs. Thus, any changes made to the resistance values is reflected in the output current in real time. If the user disconnects (or delete) any component in the active circuit, the current flow stops, since the circuit is open. Based on these the user can simulate electrical circuits in real time and can understand the working of the circuits in a virtual environment.

IV. LITERATURE REVIEW

Von Neumann cellular automata are the original expression of cellular automata.[6] In general, cellular automata (CA) constitute an arrangement of Finite State Automata (FSA) that sit in positional relationships between one another, each FSA exchanging information with those other FSAs to which it is positionally adjacent.[8] In von Neumann cellular automata, the finite state machines (or cells) are arranged in a two-dimensional Cartesian grid, and interface with the surrounding four cells.[7]

With the extensive application of computer multimedia technology, many universities use simulation software into the electronics classroom teaching process which use Finite Automata in hardware [9][10] as well as software applications. Thus, we can display abstract concepts and theories with specific graphics and sound. Using of software in the classroom simulation and presentation can enhance perceptions of students, also, in this way, students can learn both the basic use of various instruments and circuit parameters of the test methods to make teaching and learning in the classroom to form a good interaction.

A linked list is a linear data structure, in which the elements are not stored at contiguous memory locations.

V. CONCLUSION

Simulation is going to be the innovation of the future, due to its ease of functioning. Also, due to overcoming physical limitations that are possible in a real environment. So, developing a circuit simulation can be really effective especially for educational purposes, for better understanding of concepts and ideas, also implementation of the same.

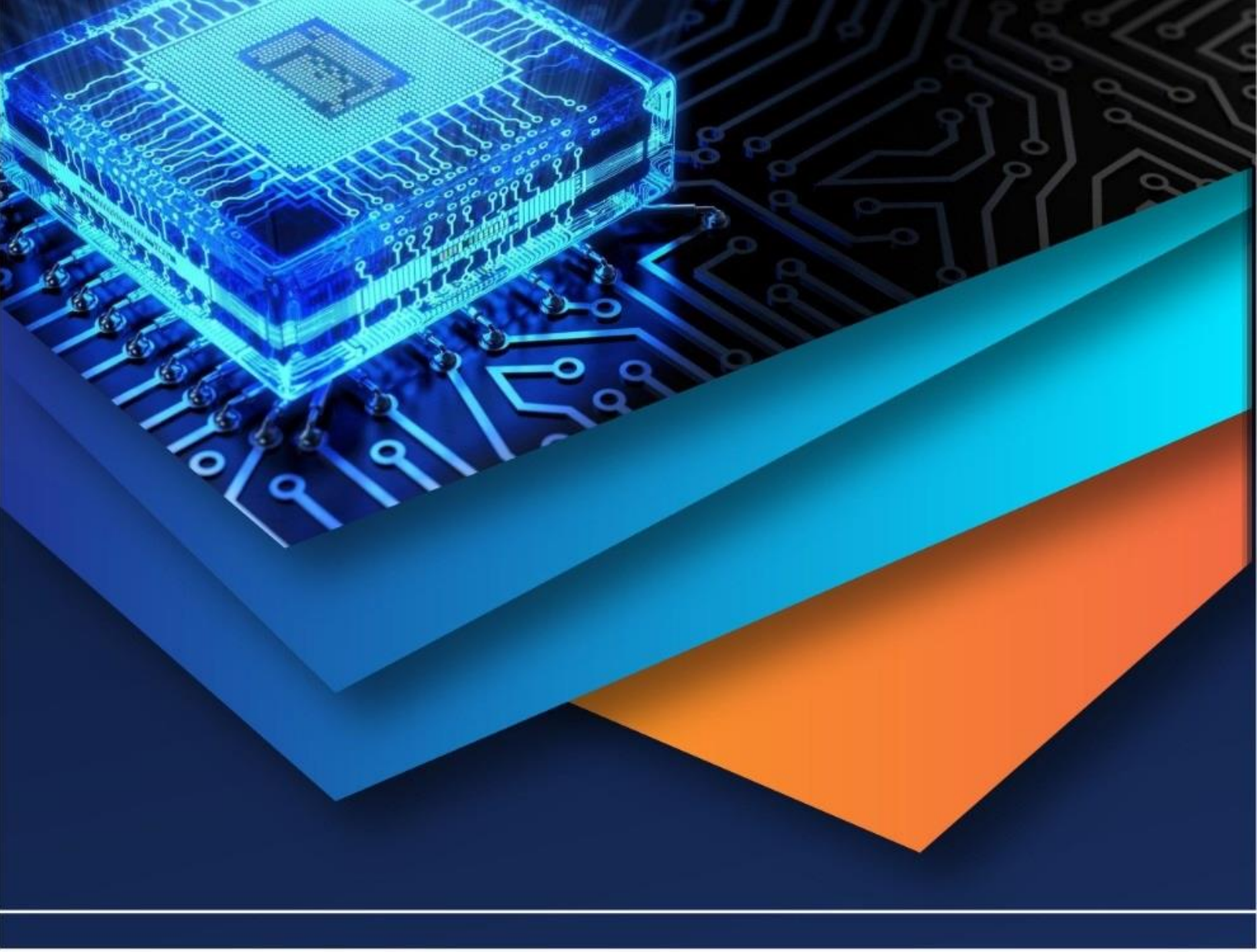
1) Future Scope: For future work, we are going to develop parallel circuits using Thevenin's Law implement KVL, KCL and Adder Circuit.

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