

Design of a Pressure Sensor Array System Based on Minecraft

Ximing Luo*

Shanghai No.4 High School, Shanghai, China

**Author to whom correspondence should be addressed.*

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Multimodal information sensing becomes increasingly critical under the rapid development of automation and information technology. With the ability to provide high-density and high-sensitivity pressure detection, pressure sensor arrays have been applied to a variety of fields, including intelligent robotics, medical monitoring, and industrial automation. This study proposes a pressure sensor array system based on the Minecraft game platform. The simulation and testing of the pressure sensor arrays system have been conducted using redstone circuits and pressure plates in Minecraft to simulate real-world piezoelectric pressure sensor arrays. A series of experiments verified the feasibility and effectiveness of the system.

Keywords: Pressure sensor array; Minecraft; Redstone circuits

Online publication: October 15, 2025

1. Introduction

With the swift advancement of automation and information technology, accurate environmental sensing and control have become increasingly important. Pressure sensors are a crucial type of sensing device that enables the detection and measurement of pressure changes. Therefore, they are widely applied to various automation control systems. While most traditional pressure sensors can only enable single-point measurements, pressure sensor arrays enhance data acquisition by enabling multi-point measurements, thereby facilitating more precise environmental sensing.

In fields such as intelligent robotics, medical monitoring, and industrial automation, there is an increasing demand for pressure detection systems that exhibit high precision and sensitivity. Consequently, pressure sensor arrays have emerged as a prominent topic of research, owing to the capacity to deliver multipoint, high-density pressure measurements.

Capacitive, resistive, and piezoelectric sensors are prevalent types of pressure sensors, each characterized by distinct operational principles and specific application scenarios.

Minecraft is a highly creative sandbox game with a built-in redstone circuit system that provides a unique platform for simulating electronic circuits. The redstone circuit system is programmable, versatile, and creative, allowing players to create complex circuits and mechanical systems through the arrangement and configuration of diverse redstone components. In Minecraft, the implementation of redstone circuits in conjunction with pressure plates allows for the simulation and evaluation of real-world pressure sensor arrays, including capacitive, resistive, and piezoelectric types^[1].

Therefore, this study aims to investigate the application of redstone circuits and pressure plates within the Minecraft environment to simulate the pressure sensor array system. The research focuses on the following elements.

2. Principle of redstone circuits

The working principle of redstone circuits is based on the signal transmission of redstone dust. Redstone dust can connect various redstone components, thereby facilitating the creation of intricate circuit systems. Therefore, the fundamental principles of redstone circuits help to understand the function of each individual component and comprehend the signaling mechanisms inherent in these circuits.

Additionally, investigations were conducted on associated digital logic circuits. The operational principles and applications of basic logic gates were researched, including AND Gates, OR Gates, and NOT Gates. Furthermore, the significance of flip-flop and latch in data storage and processing was studied.

The pressure sensor was built based on Minecraft redstone circuits. Utilizing a combination of redstone dust and a pressure plate, a redstone signal can be activated upon the presence of a player or other entity on the pressure plate. A simple circuit connecting the pressure plate to the redstone dust can ensure effective signal transmission.

Design and implementation of a test circuit for the pressure sensor array. An array equipped with multiple pressure sensors was designed. Each sensor is responsible for detecting pressure changes in a specific area. Using redstone repeaters and comparators, signals generated by each sensor were integrated to form a unified output signal. According to the design diagram, test circuits were constructed using components such as redstone dust, repeaters, and comparators.

3. Components of redstone circuits

3.1. Redstone circuits

Redstone circuit is a unique circuitry system in Minecraft that enables players to create complex logic control and signal transmission systems by placing and configuring a variety of redstone components^[2]. Fundamentally, redstone circuits possess programmability, versatility, and creativity, enabling users to construct a diverse array of mechanical and automated systems. Redstone components include, but are not limited to, redstone dust, redstone torch, redstone repeater, redstone comparator, etc., which together form the basis of redstone circuits.

3.2. Redstone components

Redstone components are fundamental for constructing redstone circuits. The detailed description of some key components is listed below:

- (1) Block of redstone: As a permanent power source, the block of redstone provides a constant redstone signal. Therefore, it often functions as a power source or signal source for circuits.

- (2) Button: Button is a common input component. The player can click it to generate a brief signal pulse that activates the connected circuits.
- (3) Daylight detector: This component generates redstone signals of varying intensity depending on the daylight intensity. It is often used to simulate daylight changes or be a functional part of a timer.
- (4) Detector rail: The detector rail detects the passage of a mine car. It sends out a signal to activate the connected circuits when the car passes.
- (5) Levers: Similar to buttons, levers can be operated by the player to activate or deactivate circuits. Moreover, their design facilitates a more intuitive method of operation.
- (6) Pressure plate: When the actions that a player or creature steps on are detected, the pressure plate sends out signals for the activation of circuits.
- (7) Redstone torch: The redstone torch not only functions as a light source, but also functions as a signal inverter and transmission component for the circuits.

3.3. Digital logic principles

The digital logic principles of redstone circuits involve basic logic gates that are critical to complex circuits. The introduction to some of the basic logic gates is listed below:

- (1) NOT gate: NOT gate is one of the most basic logic gates. It is a gate used when an opposite output is wanted from the input given. When the switch, or input, is set to “on” (1), the output toggles to “off” (0), and vice versa.
- (2) AND gate: AND gate requires that the output is toggled to “on” only when all inputs are “on.” This logic gate is often used in cases where multiple conditions need to be met simultaneously.
- (3) OR gate: An OR gate is a gate that, whenever any input is “on,” the output is also “on.” This logic gate is often used for “at least one” condition determination.
- (4) XOR gate: An XOR gate is a gate that uses two inputs and the output is toggled to “on” when one switch is “on” and one switch is “off.” This type of logic gate is very useful in figuring out whether two signals are equal^[3].

Flip-flops and latches are the crucial components for temporal logic implementation in redstone circuits. They can retain states and modify their outputs in response to input signals. Some of the common flip-flops and latches are introduced as follows:

- (1) T flip-flop: A T flip-flop is a basic flip-flop whose output toggles its state whenever the input signal T changes from OFF to ON. This type of flip-flop is commonly used to implement frequency dividers or pulse generators.
- (2) RS latch: The RS latch functions as a circuit storing a two-bit binary number. Its output depends on the state of the input signals R and S. This latch is significant in data storage and transmission.
- (3) D flip-flop: The D flip-flop is a data flip-flop whose output varies in accordance with the state of the input signal D. This type of flip-flop is highly beneficial for data synchronization and timing regulation.

4. Pressure sensor based on Minecraft redstone circuits

4.1. Construction of a single pressure sensor

4.1.1. Principle of construction

The simulation of the piezoelectric pressure sensor employs the signal generation capabilities inherent in redstone

circuits. The redstone signal is generated when the pressure plate is pressurized, simulating the charge generated by the piezoelectric material when it is pressurized. The simulation can detect and measure pressure. In Minecraft, the redstone signal generated by a pressure plate can activate a diverse array of redstone components, including gates and pistons. Therefore, the simulation can facilitate pressure detection and subsequent responses.

4.1.2. Simulation of a single pressure sensor

Initially, we conducted a simulation involving a single pressure sensor. The operational response of the pressure sensor is simulated by positioning a pressure plate and monitoring the redstone signal it generates. We established a connection between the pressure plate and a redstone lamp using redstone dust, thereby enabling the redstone lamp to activate and deactivate in response to the signal generated by the pressure plate^[4].

As shown in **Figure 1**, when there is no object placed on the pressure plate, the redstone lamp is not illuminated, and no energy is generated. As shown in **Figure 2**, when the game character steps on the pressure plate, the redstone lamp is illuminated and energy is generated. The experimental results indicate that the redstone signal generated by the pressure plate exhibits a strong correlation with variations in pressure.

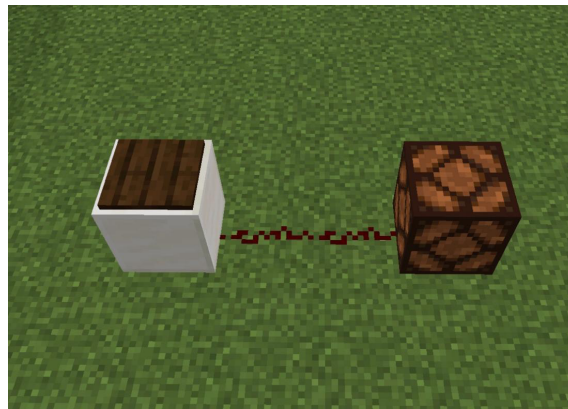


Figure 1. Single pressure sensor (no object on the pressure plate)

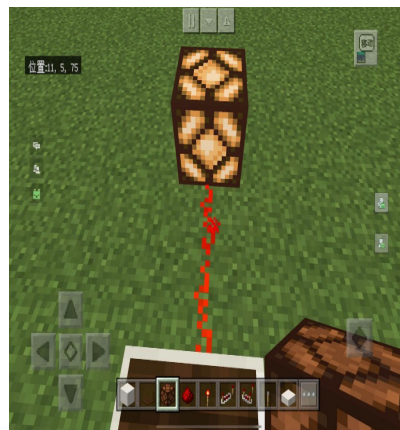


Figure 2. Single pressure sensor (game character standing on the pressure plate)

4.2. Construction of sensor array

Subsequently, a 3×3 pressure sensor array was developed. As illustrated in **Figure 3**, nine blocks of quartz were systematically organized in a 3×3 matrix configuration, with a pressure plate positioned atop each block of quartz.



Figure 3. 3×3 pressure sensor array

4.3. Construction of test circuit

To facilitate the detection of electrical signals from the 3×3 pressure sensor array, a measurement system was established (**Figure 4**). Two redstone lamps were strategically positioned at each of the four edges of the 3×3 pressure sensor array to monitor the eight peripheral pressure plates. The signal generated by the center-positioned pressure plate was routed using a lower lead to one of the redstone lamps, so that the detection of this pressure plate is achieved.

As illustrated in **Figure 5**, the illumination of the outer redstone lamp occurs when the game character stands on the center-positioned pressure plate. When the game character stands on the peripheral pressure plate, the redstone lamp adjacent to it is illuminated (**Figure 6**). It is evident that the constructed small-scale pressure-sensing array possesses the requisite measurement capability.



Figure 4. 3×3 pressure sensor array and test circuit

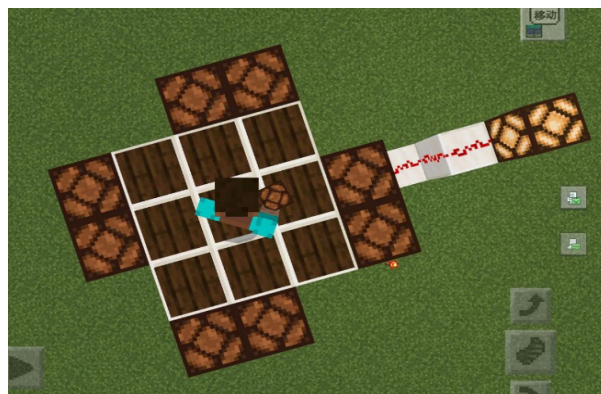


Figure 5. Game character standing on the center-positioned pressure plate

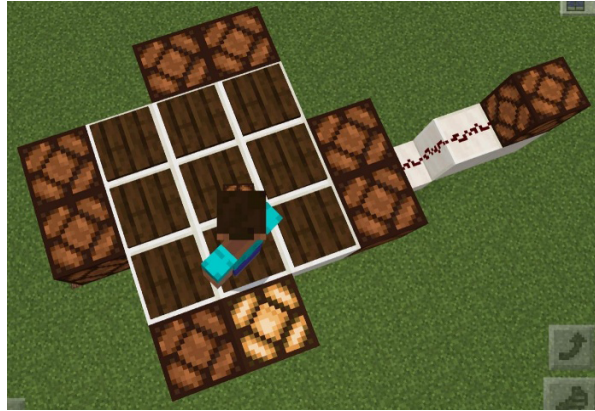


Figure 6. Game character standing on the peripheral pressure plate

5. Design and testing of large-scale pressure sensor array

5.1. Principle analysis and measurement scheme

5.1.1. Problem elicitation

In the game Minecraft, players can construct a fundamental pressure sensor array by effectively utilizing pressure plates. These sensors enable the detection of a player or an entity, thereby activating designated redstone circuits. However, as the scale of the sensor array grows, the previously simple design of the measurement circuitry will encounter significant challenges. If we continue to employ the methodology outlined in Section 4, specifically the individual connection of each pressure plate via redstone wires, the complexity and manageability of the wiring for the entire test circuit will significantly deteriorate as the quantity of pressure plates increases. Therefore, addressing this issue necessitates a comprehensive optimization of the design for the test circuit.

5.1.2. Solution

Figure 7 illustrates the working principle of the pressure sensor. The pressure plate functions as a sensing component. It is capable of transducing physical pressure into redstone signals. This process represents the initial phase in the development of a pressure detection system. The redstone circuits enable the signal transmission, transferring the sensing information from the pressure plate to the subsequent redstone devices.

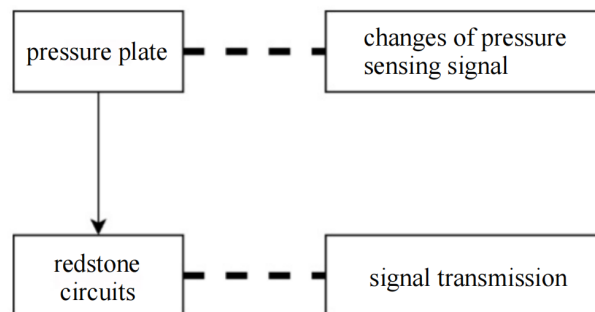


Figure 7. Schematic diagram of pressure sensing

Practical observations indicate that energy attenuation occurs in the transmission of redstone signals.

Specifically, as the distance over which the signal propagates increases, there is a corresponding gradual decrease in its strength. As shown in **Figure 8**, energy is conveyed through the redstone wire. The energy source exhibits the highest concentration of redstone energy, represented by a bright red point. As the energy is transmitted along the redstone wire, the energy intensity diminishes, resulting in a gradual transition to a darker hue. Ultimately, this energy diminishes, as indicated by the black point within the dashed box (indicating a complete absence of energy).

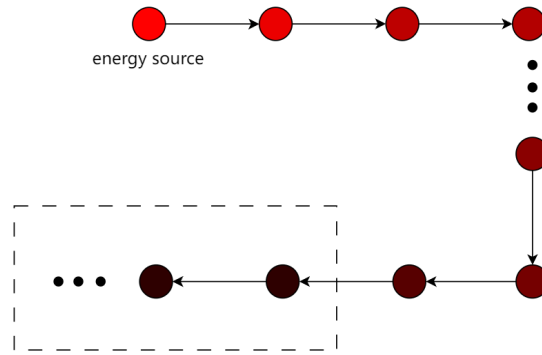


Figure 8. Energy attenuation of the signal transmission in redstone circuits

Figure 9 provides a quantitative analysis of the energy attenuation, demonstrating a linear correlation between redstone energy and path length. It indicates that redstone energy diminishes as path length increases. This relationship can be mathematically represented by the following equation:

$$\text{Redstone energy value} = 15 - \text{path length value} \quad (1)$$

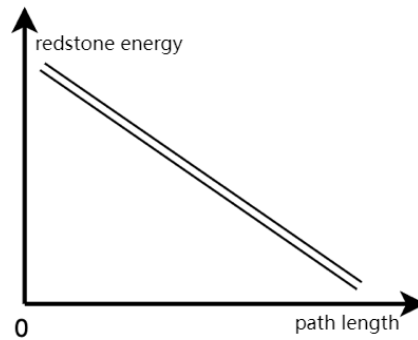


Figure 9. Relationship between redstone circuit signal transmission distance and path length

This property of energy attenuation is an important consideration for redstone circuit designers. Comprehending and implementing this principle can assist the designer in optimizing the circuit layout. For instance, the utilization of redstone repeaters can facilitate the extension of signal transmission distances or minimize energy loss by reasonable design of the circuit pathway.

In addition, deep insights into signal attenuation provide a theoretical basis for designing more complex pressure-sensing arrays. The distance from the energy source, specifically the pressure point, can be deduced from

the redstone energy value recorded at the measurement point.

As shown in **Figure 10**, a circuit layer is set up under the sensing layer (pressure plate layer). Redstone dust is positioned beneath each pressure plate within the sensing layer, and this redstone dust is interconnected to create a redstone grid. Each point within the grid possesses the capacity to be activated by the corresponding pressure plate situated above it.

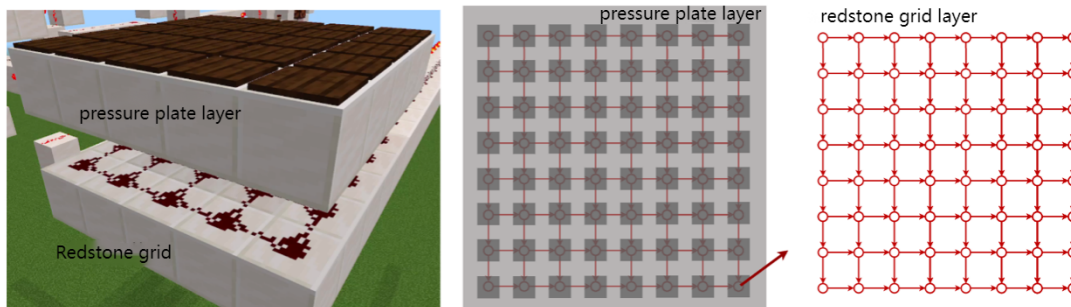


Figure 10. Redstone grid

This study investigates the energy attenuation of the redstone grid by experiments. As illustrated in **Figure 11**, a 4×16 redstone grid was constructed, with the lever positioned at the grid points located in the third row and third column to supply energy. Observations of the color variations across the redstone grid indicate that the intensity of color at the grid points correlates positively with proximity to the energy source. In other words, grid points closer to the energy source exhibit a brighter hue, indicative of a higher energy value. Notably, the energy value appears to be solely dependent on distance rather than the direction of redstone energy transmission. This hypothesis was verified by measurements taken from energy detectors situated in the first row, as well as the fourth and eighth column positions.

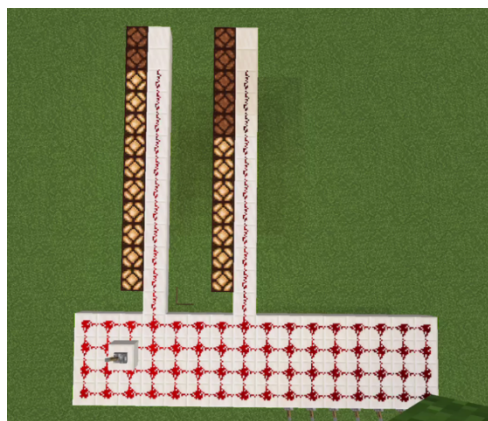


Figure 11. Experimental validation of redstone grid energy attenuation

In redstone circuit design within Minecraft, the accurate placement of stressors is accomplished through an intricate network of redstone circuits, as well as the strategic positioning of detection points at critical junctures. This methodology bears resemblance to the mathematical problem of determining the intersection of two circles.

We consider that there is a scenario involving two circles, where the center of each circle functions as a detection point, and the radius of each circle denotes the detection range associated with that point. The objective

is to identify the intersections of these two circles, which may suggest the potential location of stressors. This situation parallels a mathematical problem in which the coordinates of the centers and the radii of the two circles are known, and the task is to determine their common intersection points.

By reformulating the detection of redstone circuits as a mathematical problem, the problem can be addressed according to geometric principles. This methodology not only enhances the positioning precision but also renders the entire design process more systematic and scientific. By calculating the distance between the centers of two circles and juxtaposing it with their respective radii, we can ascertain whether the circles intersect and identify the precise coordinates of the intersection point. In **Figure 12**, the performance of the detection point is quantified on a scale from 0 to 15, which corresponds to detection distances ranging from 1 to 15 grids. A detection range can be defined as a 16×16 grid area centered on the detection point, encompassing all potential detection points. However, when the detection point is situated at a corner of the sensing array, its effective detection range is represented as a right triangular area because the detection area at the corner is constrained by the boundaries of the array. In this right triangle, the two right-angle sides illustrate the detection capabilities of the point in both horizontal and vertical orientations, respectively.

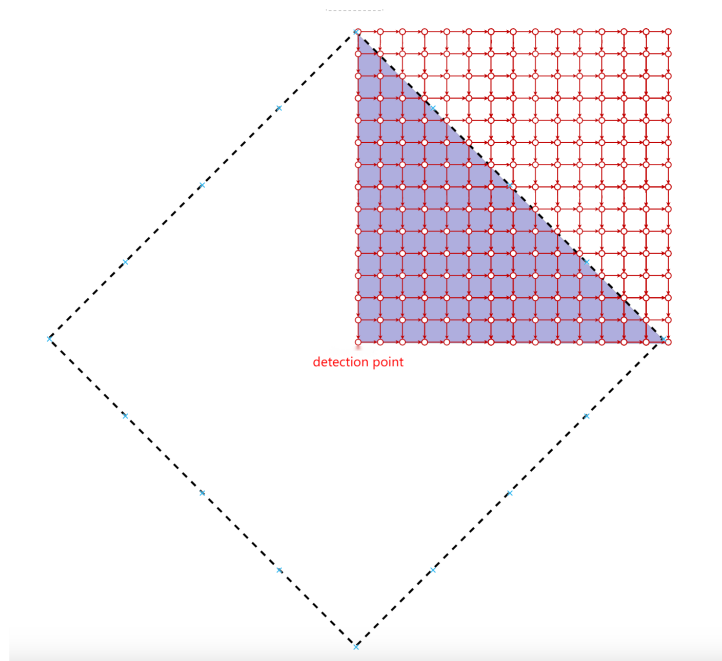


Figure 12. Detection point coverage

5.2. Detection circuit analysis

5.2.1. Conversion of energy values to digital quantities

According to the analysis in Section 5.1., the initial step in identifying the location of the pressure point involves the precise calculation of the energy values at the detection point. Considering that redstone circuits inevitably undergo energy attenuation during transmission, this attenuation can substantially influence the energy values. To address this issue, it is essential to transform the analog energy values into more manageable digital quantities. Accordingly, we propose two methodologies for facilitating the conversion from analog to digital quantities:

The first method leverages the attenuation characteristics of energy transmission. Specifically, a redstone wire is established from the measurement point, with a redstone torch positioned adjacent to the quartz block beneath

the redstone wire. The transmission of redstone energy results in the extinguishing of the redstone torch. Therefore, the identification of the maximum energy transmission path can be achieved by monitoring whether the redstone torch extinguishes. This pivotal moment, at which the redstone torch ceases to extinguish, can be regarded as a clear indicator of energy attenuation. By employing Equation (1), it is possible to retroactively determine the precise location of the measurement point. A detailed example of the circuit design utilized for this conversion is illustrated in **Figure 13**.



Figure 13. Energy numerical conversion method 1

The second methodology is more concise. As illustrated in **Figure 14**, the 16 redstone torches positioned at the bottom each represent different energy values. The illuminated torches on the left side correspond to lower energy values, while those on the right side indicate higher energy values. Within **Figure 14**, a toggle mechanism is employed to achieve a measurement point with an energy value of 11, which is illuminated as the 11th torch from the left among the redstone torches at the bottom.

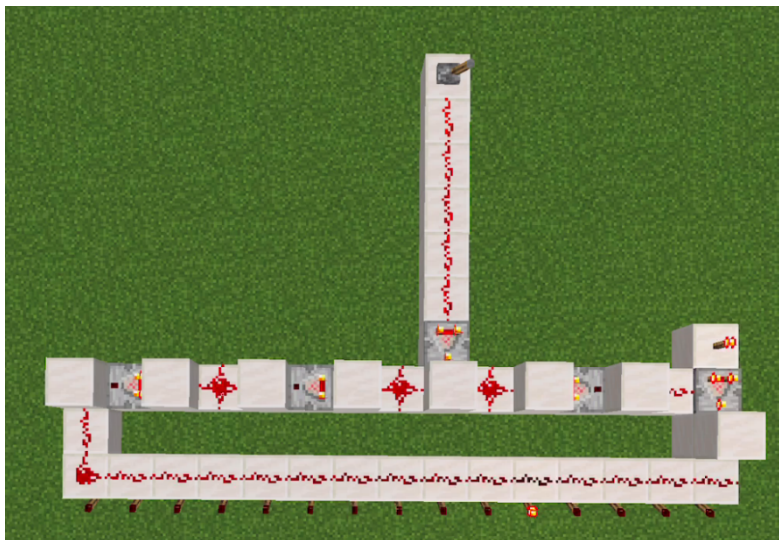


Figure 14. Energy numerical conversion method 2

5.2.2. Hexadecimal to binary conversion

According to the analysis of the previous section, the energy value is converted to hexadecimal numerical

quantities. To facilitate the subsequent calculations, it is essential to convert the hexadecimal digital quantities to binary digital quantities. Therefore, the calculation process for the measurement points is shown in **Figure 15**.

The truth table for hexadecimal to binary conversion is shown in **Table 1**, based on which the hexadecimal to binary conversion circuit is designed.

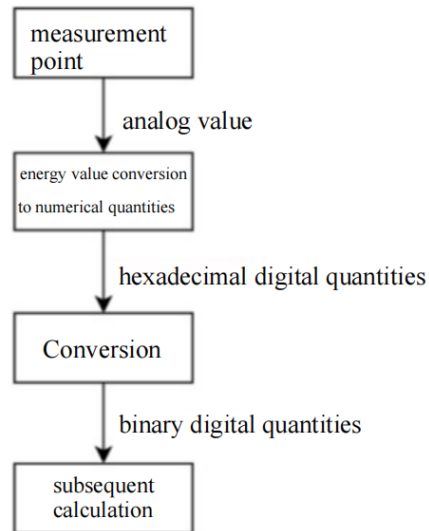


Figure 15. Calculation process for the measurement point

Table 1. Conversion from hexadecimal quantities to binary quantities.

Hexadecimal quantities		Binary quantities			
0	0	0	0	0	0
1	0	0	0	0	1
2	0	0	1	1	0
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	1
6	0	1	1	1	0
7	0	1	1	1	1
8	1	0	0	0	0
9	1	0	0	0	1
10	1	0	1	1	0
11	1	0	1	1	1
12	1	1	0	0	0
13	1	1	0	0	1
14	1	1	1	1	0
15	1	1	1	1	1

Figure 16 illustrates a highly efficient circuit for converting 1-bit hexadecimal numbers to 4-bit binary representations. In this configuration, a hexadecimal input signal is processed by the circuit to convert the

corresponding 4-bit binary output. The conversion logic is predicated on the mapping relationship delineated in **Table 1**, which associates each hexadecimal digit with its equivalent four-bit binary representation. When a bit of the hexadecimal input is activated (high), the corresponding output line in the binary digit also activates, thereby facilitating a direct signal conversion. This conversion circuit has significant advantages in enhancing data processing efficiency and simplifying circuit design.

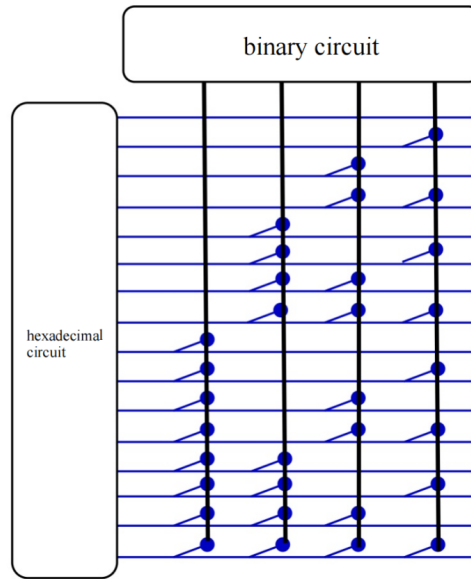


Figure 16. Principle of 1-bit hexadecimal to 4-bit binary number conversion circuit

According to Figures 16 and 17, the circuit was built in Minecraft. The measurement effect is shown in **Figure 18**. The corresponding measurement points of the foxes in different positions have different values: the distance from the foxes to the measurement point (path distance, horizontal and vertical distances are summed up) is “3,” “4,” “5,” “4,” “5,” “7.” According to **Table 1**, the values corresponding to the binary quantities are “0011,” “0100,” “0101,” “0111,” respectively.



Figure 17. Realization of 1-bit hexadecimal to 4-bit binary number conversion circuit

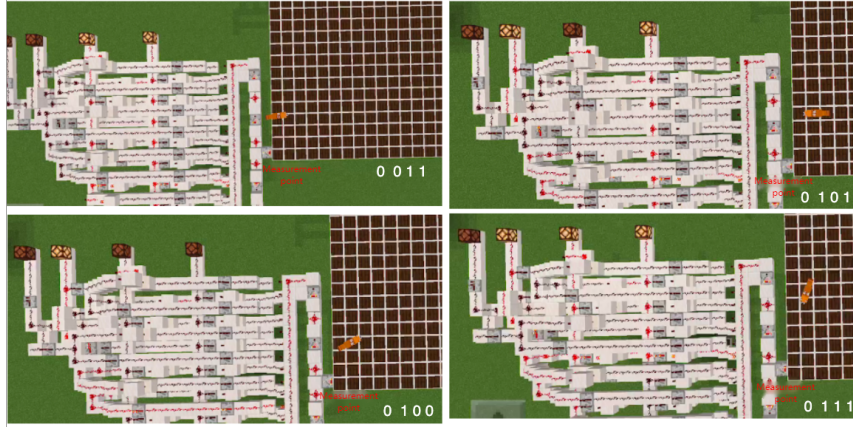


Figure 18. Measurement effect

5.3. Case study: 8×8 pressure sensor array

An analysis of the 8×8 pressure sensor array is conducted, with the model illustrated in **Figure 19**. This sensor array is comprised of two distinct components: the lower section, which consists of 64 blocks of quartz organized in rows, and the upper section, where each block of quartz is positioned atop a pressure plate.

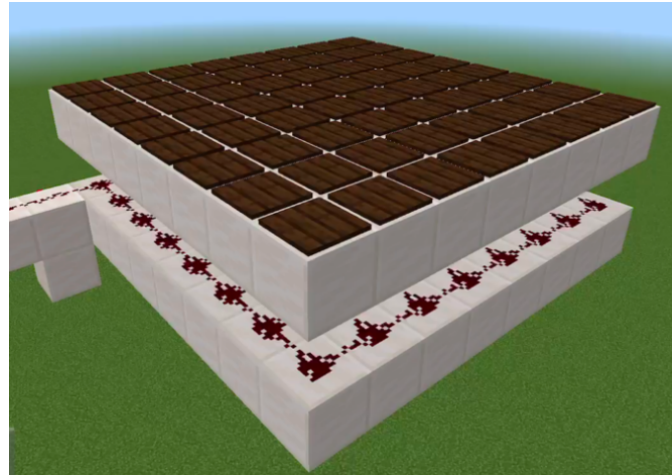


Figure 19. 8×8 pressure sensor array

For the 8×8 pressure sensor array, two measurement points can be utilized for calculation. As illustrated in **Figure 20**, the blue triangle area represents the measurement range for measurement point 1, while the red triangle area denotes the measurement range for measurement point 2. The gray square area indicates the sensing range of the 8×8 pressure sensor array. **Figure 20** evidently indicates that the sensing range is concurrently located within both the blue and red triangular areas.

By detecting the energy of measurement point 1 and measurement point 2, the Manhattan distance from the pressure point to measurement point 1 and that to measurement point 2 can be calculated. In **Figure 20**, the Manhattan distance of the game character from the measurement point 1 is 11, and that from the measurement point 2 is 12. The coordinates of the game character's position are denoted as (x, y). Consequently, the conditions for x and y are expressed as Equation (2):

$$\begin{cases} x + y = l_2 \\ x + 8 - y = l_1 \end{cases} \quad (2)$$

Therefore, (x, y) can be calculated according to Equation (2), and the 8×8 pressure sensor array completes the measurement.

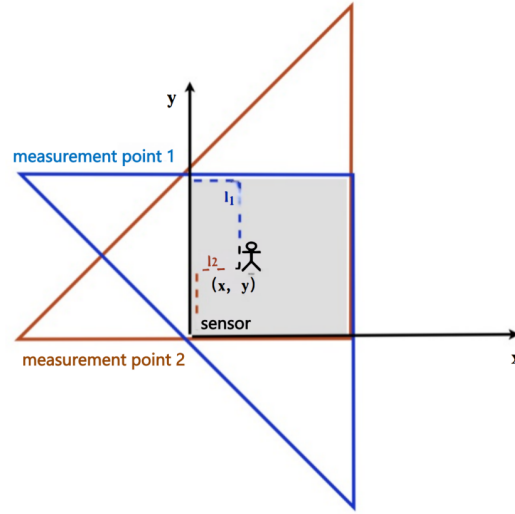


Figure 20. Measurement principle of 8×8 pressure sensor array

6. Conclusion

This paper proposed a pressure sensor array system based on Minecraft. The simulation of the operational principles of capacitive, resistive, and piezoelectric pressure sensors has been conducted, and the implementation of redstone circuits and pressure plates facilitated the simulation and evaluation of the pressure sensor array. The experimental results indicate that the system is capable of effectively simulating the detection and control processes concerning pressure sensor arrays, demonstrating significant feasibility and potential for application. Future research may focus on optimizing the redstone circuits design, enhancing the stability and accuracy of the system, and investigating its applicability in real-world scenarios.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Oussar Y, Margo C, Lucas J, et al., 2023, Fast Circular Shapes Detection in Cylindrical ECT Sensors by Design Selection and Nonlinear Black-Box Modeling. *COMPEL: The International Journal for Computation and Mathematics in Electrical and Electronic Engineering*, 36(1): 2–17.
- [2] Chen C, 2019, *Redstone Electronics: Learning Logic Circuits and Computer Principles by Playing My World Minecraft*, Posts and Telecommunications Press.
- [3] Lu X, 2014, Analysis of Physical Principles of Resistive Sensors. *Physics Teacher*, (8): 56–58.

- [4] Yao S, Mo Z, Nie L, 1990, Titrations with Piezoelectric Monitoring. *Analytica Chimica Acta*, 229: 205–212.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.