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Research Article

Designing an Intelligent Firefighting Toy Car Using AR Technology and STEAM

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For children, school-age is the best time to develop common-sense knowledge, as they need to know things by touch and direct perception. Currently, fire productions for children are the best medium for children's learning but most of the existing children's firefighting products have a single function and low interest, which cannot meet the growing needs of children and gradually cannot attract children's attention. In terms of user experience, Augmented Reality (AR), as a new technology, is easy to arouse children's interest in learning and stimulate children's curiosity and exploration. AR technology adds computer-generated writing information, pictures, virtual 3D designs, videos, or scenes to the actual background perceived by users in real-time and accurately. It recognizes the organic incorporation of virtual and real scenes, to achieve a sensory practice outside reality. Integrating this technology into the design of children's fire education products will play a role in teaching fun. Keeping the importance of VR technology in our society, this research paper designs a smart car by utilizing STM32F103 chip microcontroller as the key regulator core to regulator peripheral motorized drives, ultrasound, sensors, and other modules. Furthermore, the experiments demonstrate that the laboratory may be of practical benefit in developing learners' comprehensive capacity and practical technological capabilities.

1. Introduction

The wave of the Fourth Industrial Revolution, driven by new technologies such as the Internet of things, big data, robotics, and artificial intelligence, has swept the world. Looking at the historical process of human society's evolution, we can see that when new technologies and fields emerge, the way human resources are rapidly developing in each country changes. The Fourth Industrial Revolution, which began this century, also sounded like a clear call for the development of new talent in a new era. With these new technological changes, this revolution has infused professional and technical elements, with knowledge of the basic subjects contained therein directed directly to science, technology, engineering, and mathematics. At the same time, in the context of the common development of globalization, countries have a strong demand for the application of emerging technologies in the field of intelligent fire protection. Their purpose is to address the hidden dangers of public safety and reduce the occurrence of fire accidents, increase fire protection.

In addition to the above, VR is a scientific technique and technology that was invented and gradually built by humans in the process of investigating, analyzing, imitating, and eventually better adapting and utilizing nature. It incorporates computer and sensor technologies, as well as interdisciplinary expertise such as artificial intelligence and electronic technology. Through multisource data fusion, interacting three-dimensional virtual sceneries, and particular virtual equipment, the virtual environment creates a digital visual experience that is remarkably comparable to the actual world [1]. It is now widely employed in entertainment, defense, medicinal, and other areas. As a novel interactive medium, its use in education is becoming increasingly widespread. Learners can connect with virtual reality-created digital learning environments to get comprehensive sensations, enabling independent learning in a comparable real-world context [2]. The virtual learning materials may be coupled and linked with the actual teaching environment. In addition, their qualities are similar to the STEAM education concept, which allow students to learn information while inspiring imagination and creativity. The authors of [3, 4] review the application of smart equipment early on in their paper. The authors of [5, 6] demonstrate that scholars have differing perspectives on the use of STEAM to AR smart fire prevention in the middle and late stages. We highlight several of the challenges that smart fire toy vehicles face in the STEAM exercise. At this moment, the study is mostly focused on specific themes or areas of STEAM virtualization.

This research primarily studies the use of VR and STEM technology to enable school-going children to quickly acquire knowledge, as school-going children have the best time to learn. However, the things that need to be known through communication and direct perception and children's fire products are the best media [7]. At present, the existing toys can no longer meet the growing needs of children and gradually cannot attract children's attention. In terms of user experience, VR is a new technology. It is relatively simple to stimulate children's interest in learning and promote their curiosity and discovery if this technology is brought into school-age children's learning.

The key contributions of our paper are listed as bellow:

(1) This study combines the creation of a firefighting toy car laboratory with the STEAM strategies of the students, and with the STEAM education concept as the driving idea, builds an AR intelligent firefighting toy car laboratory for the integration of interdisciplinary knowledge.

(2) It creates the aforementioned toy vehicle by using the STM32F103 chip microcontroller because the primary regulator core to operate outer motor drives, ultrasonography, sensors, and other components.

(3) After a lot of fixing and test verification, it succeeded in achieving independent tracing, difficulty prevention, and flame.

The rest of this paper is organized as follow. Section 2 discusses the augmented reality system and STEAM intelligent firefighting goal, Section 3 is the design of the STEAM smart firefighting toy vehicle, Section 4 is our analysis of the proposed system, and Section 5 is the conclusion of our work.

2. Augmented Reality System and STEAM Intelligent Firefighting Intension

In this section, first we discuss the augmented reality and virtual reality followed by STEAM intelligent firefighting intension.

2.1. Augmented Reality System and Virtual Reality (VR)

2.1.1. Augmented Reality for Kids. AR is an improved depiction of the real physical universe created possible by using electronic visual components, music, or other sensory stimulation transmitted via technology. The augmented reality technology is used in the manufacturing of electric products to enhance children's perception of new and unknown items. In conjunction with the advancement of three-dimensional innovation, which makes the preceding two-dimensional environment more alive and vivid, a plethora of augmented reality tools, such as Unity 3D, 3D Studio Max, and ARToolKit, have come to our attention [8]. Virtual objects that do not present in the actual world may be created and precisely blended with reality with the help of computer graphics and visualization technologies [9]. As a result of sensors and virtual or augmented innovation, youngsters can enjoy a dynamic experience of the actual world. Unfortunately, there are still some shortcomings. Whereas kids can view fake graphics similar to what they see in real life, they cannot engage with these virtual items. As a result, some interactive elements of the educational goods are required. This study develops interactive behaviors and procedures for aiding children to fondle bees and regulate their movement with hand signals, resulting in a realistic animation for kids and an amazing long-term memory.

2.1.2. Virtual Reality (VR). VR is the real-time and accurate superposition of computer-generated text information, images, virtual 3D models, videos, or scenes into the real scenery perceived by users. It realizes the organic integration of virtual scene and scene. In addition, it achieves a sensory experience beyond reality. Integrating this technology into the design of children's fire education products will play a role in teaching fun.

Its functions are as follows:

(i) Users download AR microfire simulator app in advance.

(ii) AR (augmented reality) technology is added to the microfire simulator and used in combination with a mobile phone or tablet computer.

(iii) If children's physiological behavior is more active, they will damage or stack items at will during use, and the deformation mode has the function of loss prevention.

(iv) The video camera function enables children to record virtual firefighting scenes and share them with friends and parents.

(v) The camera on the front end of the AR mini fire truck, as well as a mobile phone camera, may be utilized to flip between the first-person and third-person perspectives, as illustrated in Figure 1.

The working mechanism of VR toys are as follows:

(i) Press the direction key to control the driving of the vehicle.

(ii) The virtual flame will appear randomly.

(iii) Real toy fire truck, control and move to the fire source to put out the fire.

(iv) Press the deformation button and the box will become a car.

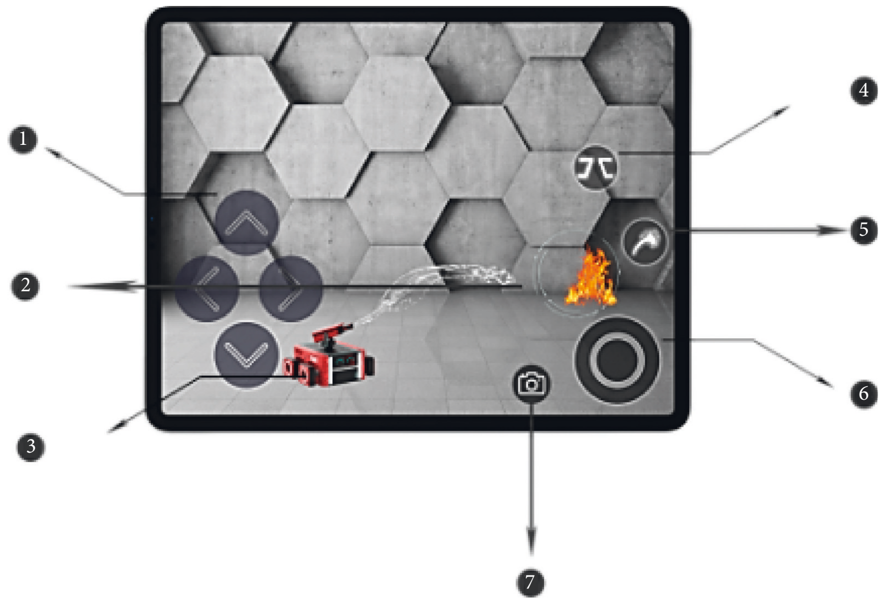

Figure 1: Schematic diagram of VR toys.

(v) Press the water spray button to spray virtual water.

(vi) Water gun control button to control the steering of the water gun.

(vii) Video camera function, long press to switch the viewing angle.

2.2. STEAM Intelligent Firefighting Intension. Since the twenty-first century, the term STEAM is more than just a buzzword, which now refers to reform movements in many systems around the world. The United States, China, Germany, the United Kingdom, the Netherlands, Japan, South Korea, and other countries have each developed several STEAM-related policies and standards in the area of fire protection to meet the needs of national conditions. With policy, market, and social encouragement, more and more researchers are discovering, researching, and evaluating the applied value of the fusion of their own intelligent fire protection systems and the STEAM concept under social and cultural backgrounds. STEAM Concepts and features have different meanings. After organizing the existing domestic and international STEAM conceptual literature, we can see that the meaning of STEAM in the academic field has the following aspects.

The STEAM education concept has several unique characteristics in education, including interdisciplinary, situational, intriguing, creative, creative, cooperative, experiential, and multidimensional, and its teaching techniques are various. We employ virtual technology to promote learning for STEAM project learning, as well as to generate new ideas for STEAM learning material creation [10]. Combining the STEAM concept with the whole virtual scene production process, combining knowledge from many areas, and encouraging students to use the connections between varied disciplines to address real-world problems and accomplish particular educational goals. Simultaneously, it is useful for the objective analysis and feedback of learners' achievement in learning, which is conducive to reinforcing the learners' understanding of the content and clarifying their weaknesses and strengths, when merged with the curriculum standards of each topic to give the idea scoring standards. Figure 2 compares the education system of STEAM and virtual Reality.

STEAM intelligent firefighting focuses on the prompt rescue of hidden fire risks and the intelligent capacity of fire extinguishing in real life via multidisciplinary integration. It has two meanings: one is the emphasis on essential requirements, acquisition of basic topic knowledge, integration of interdisciplinary knowledge, and transfer of extensive knowledge, while the second goal is to increase suppleness and learning abilities through project-based learning approaches, practical practices, thoughts and ideas, communication, and teamwork. Guess aims to implement the technological breakthrough of intelligent fire prevention. As a result, it develops a compound intelligent fire engine to improve national safety and competitiveness in fire prevention.

3. The Design of STEAM Smart Firefighting Toy Car

3.1. The Whole Strategy of the Intelligent Firefighting Car Scheme. The general form of the smart fire truck system described in this work is seen in Figure 3. A voltage regulation component, primary regulator component, motorized drive component, monitoring component, ultrasonic difficulty detection component, and flame suppression component are the key components of the system. The key regulator component is the central of the scheme's overall operation, allowing each module to send and receive data simultaneously and send corresponding instructions to drive and regulator every element after processing and analysis.

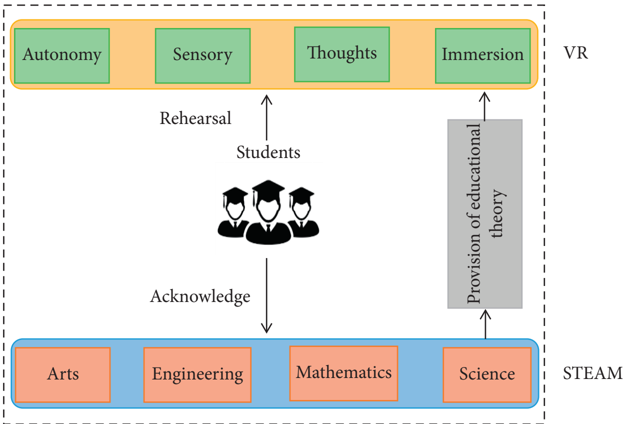

FIGURE 2: Combination of STEAM and virtual reality education.

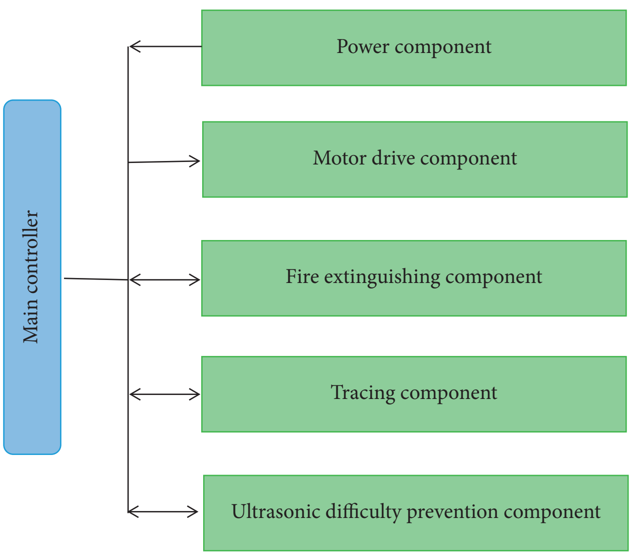

FIGURE 3: System block diagram.

From the above figure, we can see that the key regulator is straight linked to the motorized drive and can obtained the four-wheel motor directly with the help of the level indication regulator production to provide turning and forward and backward control for the smart mobile platform. Firetrucks and under-chassis installation. The RPR-220 reflective sensor of photoelectric allows clever fire trucks to follow a given black line. Furthermore, we built and installed an ultrasonic detecting module that can recognize the position of obstacles when complicated smoke is formed and determine the smart car's front/rear, steering, and stop. When a motor powers an intelligent fire engine, the fire extinguishing module receives the detecting signal and transforms it into an electrical signal, which is then delivered to a single-chip microcontroller for processing. The regulator directs a level indication to drive the microdevice for water pumping. Figure 4 explains the flowchart of our proposed system for firefighting toy care utilizing fire and ultrasonic sensors.

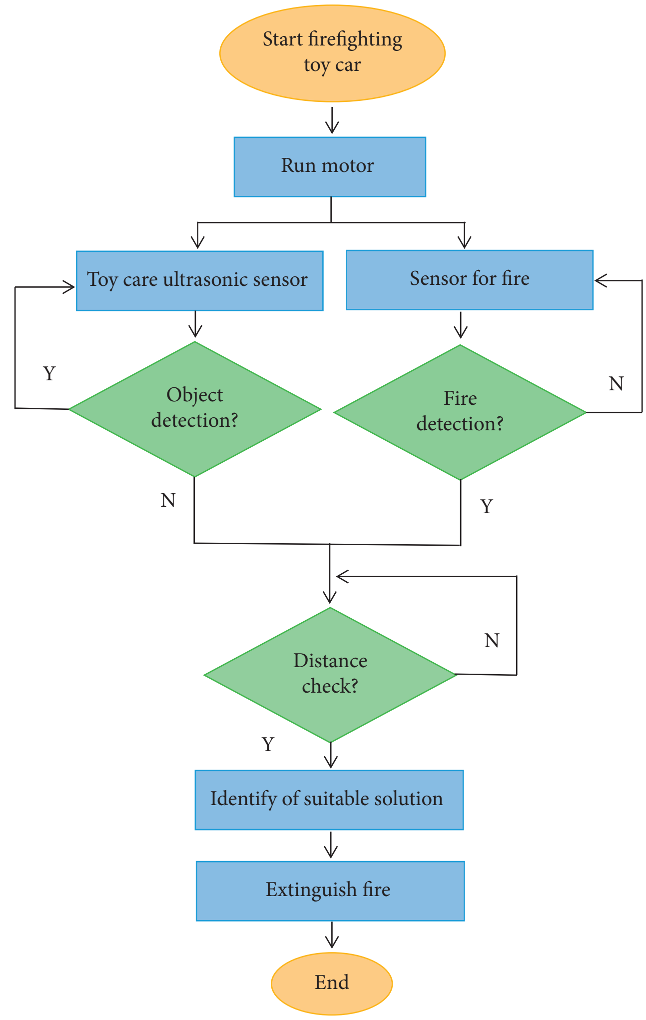

FIGURE 4: Flowchart of our proposed system for firefighting toy care.

3.2. *Circuit Strategy for Hardware and Examination*

3.2.1. Key Regulator Component. The system's key control unit is the intelligent fire engine's fundamental component, and it incorporates the duty of transmitting and getting commands to operate external and internal components. The key chip choice is the STM32F103 processing circuit that is a 32 bit microregulator, with storage of program capability of 64 KB and an operating voltage (LDAP) of 2 to 3.6 V, and has extraordinary efficiency. Resources in the core include a 12 bit conversion from analog signal to digital, PWM clock, and quick integrated storage. This chip is quick, requires little power, is inexpensive, and has an abundance of external and internal resources.

3.2.2. Control Component. The control component is accountable for powering the expansion board and peripherals. The scheme utilizes two lithium batteries (rechargeable) in series as batteries and has two regulated power supplies. CPU and peripherals have the power of 3.3 V and 5 V respectively. Figure 5 depicts the 5 V voltage stabilization component, which employs the switching controller chip LM7805CV. Figure 6 depicts the 3.3 V voltage stabilization component that employs the flipping controller chip AMS1117. The most popular variable voltage microchip is the LM7805CV.

Because the voltage output reaches 1.5 A, no external correction element is required. The built-in current control circuit considerably enhances power output consistency. The AMS1117 is an electrical component with a positive low dropout. The voltage at the output is 3.3 V.

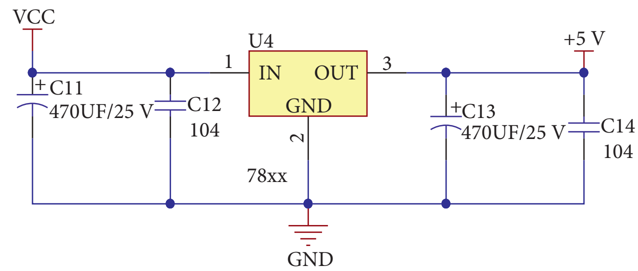

Figure 5: 5 V voltage regulator module.

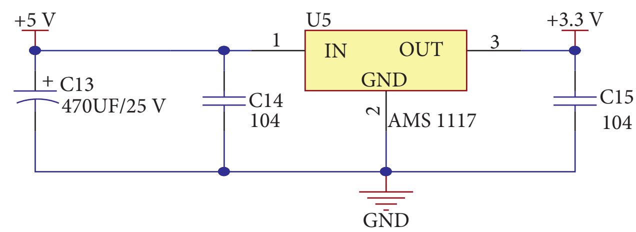

Figure 6: 3.3 V voltage controller module.

3.2.3. Motor Drive Module. The L293D motor driver chip is used in this article for the motor drive. The microcontroller's PWM speed control signal controls the output of current of the L293D, and the quickness of the motor is regulated to fulfill the aim of speed control. On the left and right sides of the cart frame, there are 2 sets (DC motors) are installed, among 1 is fitted with a chip of L293D drive for controlling. The motorized drive component's IN1 and IN2 logic ports are independently linked to the IO port of the individual chip computer and allocated to IN1 via the individual chip micro controller. During driving, the IN2 pins are given various low and high values. The chip's H-bridge supplies motor rotation direction and regulates power. Table 1 depicts the vehicle's driving orientation.

Table 1: Comparison of motor drive.

EN1	IN1	IN2	Dispenser operating condition
Y	*Y*	*N*	Onward
Y	*N*	*Y*	Back
Y	*N*	*N*	Constraint
N	*x*	*x*	Break

3.2.4. Flame Component. The layout of the flame extinguisher is comparatively simple, the component consists mostly of flame of infrared detectors, relays, and small water pumps and the flame detectors consist of photosensitive parts for flames. The flame intensity is sensed and the detected indicator is sent via the controller to the smart fire recognition toy car. The location can be detected using the flame inquiry of the sensor's flame that can identify the electric indicator. Fire Source Detection or Wavelength Detection for fire sources in the range of 760 to 1100 nm, the sensor board interface can be connected in a straight line to the IO port of a microcomputer with individual chip. Whenever, the flame sensor senses and approaches the flame, the green indicator light at the upper lights. The DO electronic switch outcome is low rate. The indication light will be turned off otherwise. The smart fire truck in the system sprays fire with a water pump, a photodiode shutter paired with a triode to regulate the circuit interrupt, and an intermediary relay to regulate the water pump switch. Whenever the infrared light sensor senses a flame in the preset region, the smart fire truck will begin spraying water and finish the fire suppressing activities.

4. Analysis of the Proposed System

4.1. Design Goals of STEAM Intelligent Teaching Aid. By organizing and analyzing the design characteristics and attractiveness of value of STEAM Smart Teaching Aid, designers can determine the design goals of the product practice process. Therefore, the design goals for STEAM Smart Teaching Aid are:

(i) Practical ability of children using smart teaching aids. In the process, you will learn knowledge of STEAM-related fields at the same time.

(ii) Use the materials to improve your child's ability to solve real-life problems, improve innovative and creative thinking, and develop future talent in 4C. Core functionality in all respects.

After clarifying the design goals, we looked at existing implementations of STEAM education in the market, compared them and looked for design opportunities, and found that children's programming was fully integrated into the concept of STEAM education. I found out. Children's programming is an important implementation method to develop their STEAM abilities and improve their students' innovative thinking and problem-solving abilities. Programmable materials are a type of STEAM intelligent materials. Incorporating programming into the design of materials can stimulate children's creativity rather than memorizing in the classroom. Children's programming learning is almost the same as STEAM education.

4.2. User Demand Analysis Based on FAST Method

4.2.1. FAST's Functional Analysis Method. The FSAT method is an abbreviation for Function Analysis System Technique, which is a top-down systematic analysis method for product functions. The authors of [11] have a complete definition of how FAST can be functionally analyzed in the book Product Design. They stated that the FAST technique may be utilized to define product functionality and highlight establishment during the product development and design phase. System analysis diagrams and studies that emphasize functions define the master-slave connection of functions and focus on critical functions to raise the product's value.

The FSAT approach evolved from the value engineering (VE) hypothesis developed by general motors engineer Lawrence Miles in 1961. Value engineering is a systematic, state-of-the-art management technology that emphasizes the use of existing methods and technologies. Alternatively, identify the factors that affect a particular service process, effectively identify those that do not or have little impact on your needs, and optimize and improve them. The core element of value engineering lies in the analysis of the importance of its function. Based on this feature, Miles suggested that "feature" is the essence of the product and that the product is the only carrier, in which it exists and can be realized. He then widely applied the theory of value engineering to product design. In 1965, Bayside Building was the first to propose the concept of functional analysis system technology (FAST) at the annual meeting of the American Value Engineers Association, based on the core factors of Miles value engineering theory that emphasizes functionality.

4.2.2. Product Black Box Model. The black box model is a construction method for rationalizing and analyzing the basic functions of the FAST method. The term "black box" in this type of context usually refers to an unknown system or complex area. As a result, the black-box paradigm may be utilized to solve increasingly complicated system problems successfully. In other words, from the system's point of view, we comprehensively and comprehensively investigate the relationship between the whole and part of the investigation target and the whole and the external environment to achieve the optimum problem-solving purpose. The mode of operation of the black box model starts from the user's expected demand for the product, and the entire system is optimized in the "input-operation-output" method. As shown in Figure 7, the input is the user's expected demand for the product, and the operation is the designer's analysis of the expected demand, which is converted into a product function. The output is the user's demand that acts on the product itself to achieve the rationalization of the function.

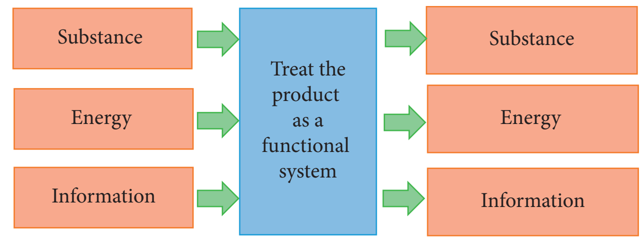

Figure 7: Black box model.

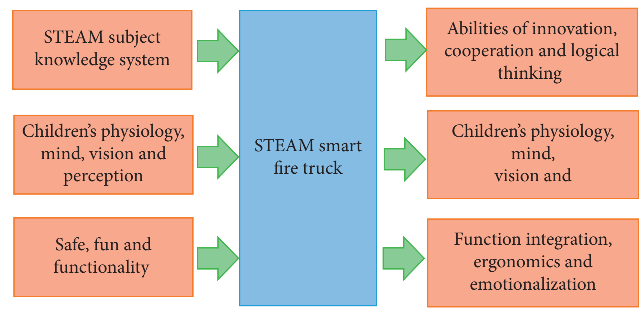

Figure 8: STEAM smart fire truck model.

4.2.3. Building FAST Functional Structure Model. Through early classification and analysis of research results, the user's actual needs for product features are captured, importance levels are categorized, and core needs are abstracted into a black box function model for STEAM intelligent materials. Figure 8 shows STEAM smart fire truck model. In this link, the inputs and outputs are converted based on the core requirements. This model contains three inputs and outputs: matter, energy, and information, and is established by an input-operation-output model. Building a black box model gives designers a clear and intuitive understanding of key features, features of product and Structural technology.

This figure shows that the product establishes a design system model using an input-execution-output paradigm. The design system converts a child's STEAM smart material demands into design features, technical difficulties, and child STEAM smart materials. Material, energy, information, and other techniques are used to transform user expectations for a product into the required product functionality output. In the learning process of children using STEAM intelligent materials, how to transform the application of the STEAM interdisciplinary knowledge system into the capacity building is an important design issue. The previous article passed STEAM's demand analysis and research and demonstrated children's programming learning by using a child's programming technology career to improve STEAM-related knowledge and children's overall strength in this process. Children's products should be created with physical, psychological, and behavioral features of children of all ages in mind. As a result, the design of children's items should be distinct. In addition to the output of information flows, the design should include functional integration, ergonomics, environmental protection and safety, learning, and entertainment.

Our suggested steam-based system for AR intelligent firefighting toy care automatically locates and extinguishes fires under the operator's direction. The operator may track the position of the fire using a mobile phone camera. Figure 9 depicts how the time it takes to extinguish a fire varies with the distance between our suggested toy car and the fire.

Figure 10 shows that the time necessary to get to the fire spot is dependent on the distance of our recommended toy care route. According to the trial results, the time required to get to the fire spot is directly related to the distance path of fire-fitting toy care.

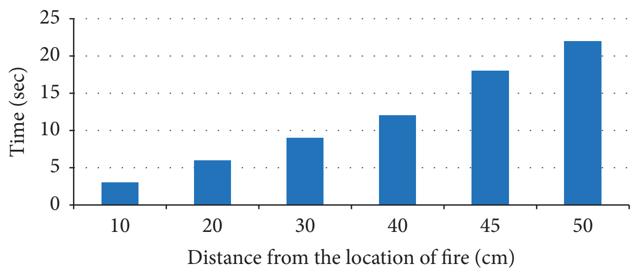

Figure 9: Comparison of time taken to extinguish a fire spot.

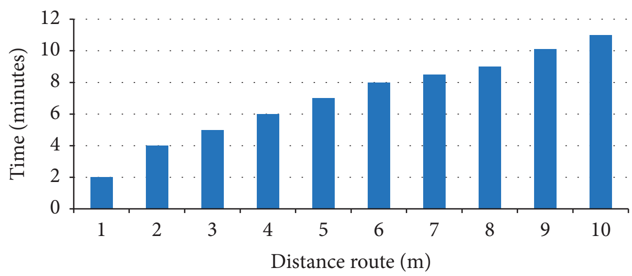

Figure 10: Comparison of time necessary to get to the fire spot.

5. Conclusions

In conclusion, intelligent firefighting toy care that can be controlled remotely has been constructed successfully utilizing the STM32F103 single-chip microprocessor as the central regulator core to operate peripheral motorized drives, ultrasonography, sensors, as well as other components. Because of the use of an ultrasonic sensor, our suggested fire-fitting toy care may prevent colliding with any obstacles or nearby objects. It may also be employed in places with a small entry or in limited areas due to its compact structure. The operator can extinguish the fire from a greater distance by utilizing a remote control. According to the trial results, our toy car can detect smoke and fire effects in a short time. Furthermore, smart fire extinguishing trolleys are appropriate for fire protection in big warehouses, combustible and explosive enterprises, and huge petrochemical firms, and have an applied benefit in enhancing product protection. As a consequence, our proposed system accomplished its goal satisfactorily.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

There are no conflicts of interest.

Acknowledgments

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