An Automatic Street Light with Motion Activation

Surya Shekhar Deb[1], Pranjal Bhattacharjee[2], Nandini Roy[3], Subha Gaurab Roy[4*]
[1, 2] Student of 6th Semester, CBCS Course, S. S. College, Hailakandi, Assam, India
[3]Assistant Professor, Department of Physics, B. Borooah College, Guwahati, Assam, India
[4]Assistant Professor, Department of Physics, S. S. College, Hailakandi, Assam, India

Abstract

As a focus on power-saving and intelligent city, the demand of intelligent lighting is becoming more and more. The design For the SMART street light A cost effective, efficient and Robust design This paper only deals with the replacement of Power wasting street lights by completely automated system based on Motion Detection, which needs to be turned ON only in Dusk. Built with parts including an LDR, HC-SR04 ultrasonic ranging sensor, and a set of LED modules controlled by an Arduino microcontroller, the system adjusts lighting in the room according to current environmental states. We intend to highlight the use in smart city-rich contexts, thus aiding in the sustainable urban development.

Keywords: Smart lighting, Energy efficiency, LDR, Ultrasonic sensor, IoT-based lighting, Smart city.

1. Introduction

Public street lighting is an important factor in the maintenance of public safety, security and the appearance of an urban environment. However, existing systems are inefficient, as they are active all night, irrespective of the presence of humans or vehicles. This causes energy to get wasted significantly and generating high operational cost. To the best of our knowledge, our proposed system presents the first ever solution of being fully automated by turning street lights on only when darkness and motion are sensed in the area, in order to save energy and prolong the street lighting component life. It’s an idea that came together through co-innovation with ideas spilling over from our earlier efforts.

2. Technologies and components Used

Arduino Uno: It's straightforward to program, beginner friendly, and has plenty of input and output pins to accommodate sensors and LEDs.

LDR (Light dependent Resistor): It is a cheap and simple way to find the light intensity (i.e., day or night).

HC-SR04 Ultrasonic sensor: It is used for precise and non-contact motion detection. It's utilized in place of PIR as the essential sensor, it's more exact and has a more extensive range capability.

* Corresponding Author Email: roysubha84@gmail.com
Published: 25/03/2025
DOI: https://doi.org/10.70558/IJST.2025.v2.i1.241074

LED: Energy saving, long service life, strong enough to duplicate a mini streetlight.

Breadboard: Great for prototyping and testing without soldering. Changing in circuit is easy for testing.

Jumper Wires: Easy to use for circuit connection, reusable and more flexible.

Resistor: It is to be included to prevent the flow of very high current through LDR and LED.

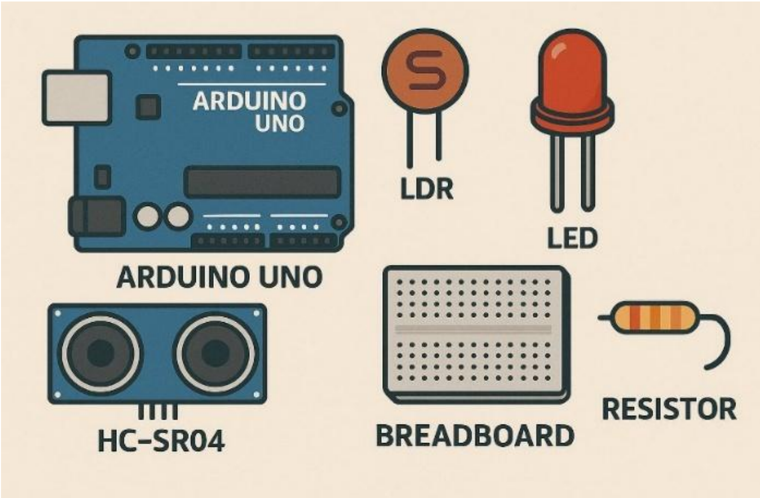

Fig.1: An Overview of the Components Used

3. Need for the System

Street lighting is an essential requirement for public safety and visibility, but it has some major problems with the existing systems. Street lighting commonplace amount of energy to from nightfall to dawn many times a day no matter how some would not dare to dream at all nothing throughout the night that wastes an enormous measure of power consumption especially where not crowded you with this evening. Old systems of manually turning the lights on & off require additional human energy and are susceptible to error. This is very slow as well and so it is not suitable for environments where things change in real time. As the global energy prices squeeze reaction around the world, the lifecycle operation of outdated lighting systems remains an everyday.

Smart infrastructures are necessity for the upcoming urban growth and growing population. The bottom line is that the smart cities of today need intelligent lighting systems to adapt dynamically in real time, use resources efficiently and help achieve other wider goals set for this new era. The proliferation of the Internet of Things (IoT) and embedded systems have made automating public utilities a viable prospect. There is a pressing demand for such systems that are not just energy-efficient but they should also be able to take autonomous decisions on the basis of inputs obtained from the surroundings respectively.

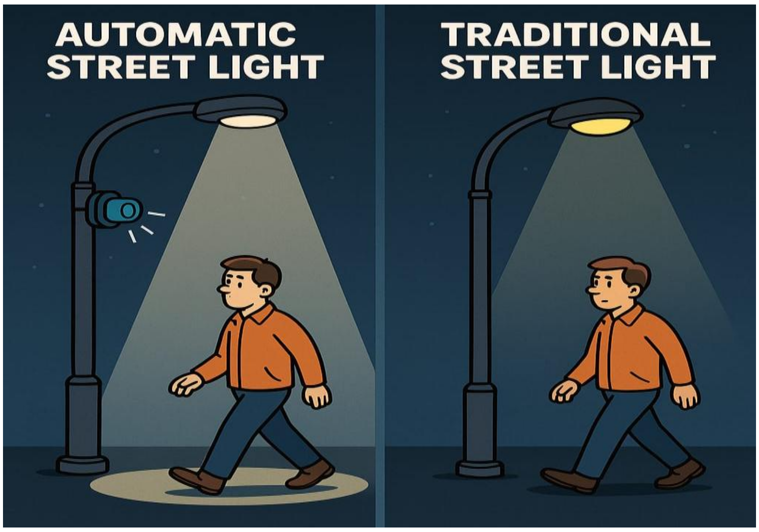

Fig.2: Pictorial comparison between Automatic and Traditional Street Lightning

4. Management Perspective

This is true only for the street light work on dual condition logic Light OR Light & Motion. Low Ambient Light   with the help of LDR the system will only work in the evening when there is no or low light. Ultrasonic sensor HC-SR04; If a person, vehicle or object enters the detection range of an Ultrasonic sensor HC-SR04, using a blend of these 2 sensors, the lights are dimmed or closed when it is light up or there is not any specific presence activity around. This way, the system offers optimal public safety, energy savings and operation convenience by responding only if there is a true need for a response.

There are some of the strategic advantages for practicing firms to adopt such a system. Indeed, studies and simulation had indicated that the live saving would be up to 75% thanks to lights only being on when necessary. When fixtures are maintained, it reduces the cost of maintenance for you and with a longer life of every component, the lights are repaired or replaced less frequently. The consumption of electricity is reduced, thereby encouraging non-consumption from non-renewable sources which can be sustainable if led infrastructure development efforts are made towards a better climate. Being modular and sensor based, this system can go hand in hand with IoT based urban networks, allowing for future expansions which can be monitored from afar enabling data driven decisions pertaining to city planning. In large public as well private infrastructure the system reasonable due to low electricity bills, over time savings of thousands and more from a lesser bill will repay the system. Though it satisfies their immediate operational want, this is moving them one step closer to the future of more sustainable and smarter cities.

5. Objectives of the Study

- To develop and assemble a power-efficient automatic street light system.
- To prove that motion detection is highly beneficial, in conjunction with light sensing.
- To evaluate whether such systems could be scaled up.

- Their goals to examine economic and environmental advantages.

6. System Architecture and Component Overview

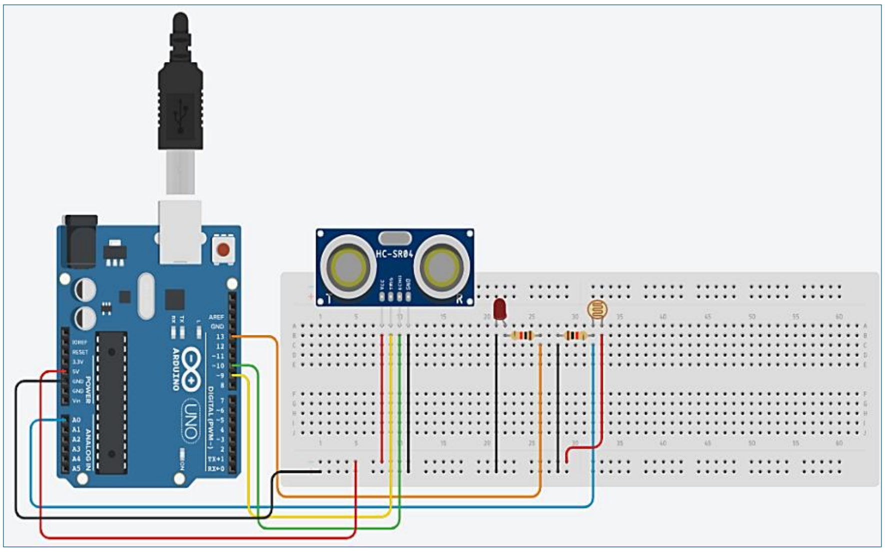

Fig.3: The Entire Design System Model

Component Functionality:

- LDR: Monitors ambient light level.
- HC-SR04: Measures object proximity.
- Arduino Uno: Handles inputs and outputs.
- LED: Aspect of the automatic street light.
- Source of power: Power supply to the circuit.
- The HC-SR04 ultrasonic sensor is used for object sensing.
- The light falling on LDR is of low/minimum intensity.
- Arduino IDE is used for programming while Tinkercad platform is used to simulate circuits and for circuit validation.

We have found that the resistance of LDR is low in light and increases significantly in dark. The Arduino monitors the voltage of the sensor by the help of its A0 pin. Now here the Light Intensity (in my case 400) is defined as threshold level above which the system doesn’t do anything. Once the light intensity goes below that threshold the LDR signals the Arduino, which then gets into motion detection mode. If movement is detected at a certain distance, (5 cm for this project), the Sensor sends the signal to the Arduino. As we know when signal from both the LDR and HC-SR04 sensor intercepts Arduino, it sends a higher signal to the LED pin (LED turn on).

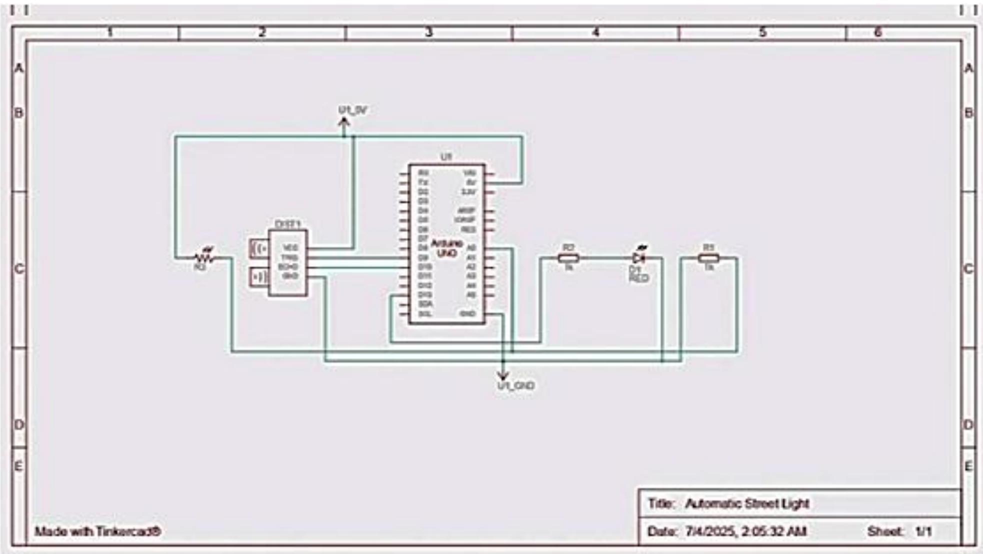

Fig.4: Schematic View of the Designed Model

Fig.3 shows the entire designed model of the system whereas Fig.4 shows the same design in schematic view. From the model we can see that the illumination of the LED depends on two conditions (both of which must be met at the same time).

7. Working Principle

The project is simple, but it works on the most effective concept of ambient light sensing and motion detection for management of lighting loads in an intelligent way. Headed up by some smart pieces: the LDR (Light Dependent Resistor) and a HC-SR04 ultrasonic sensor, both linked to an Arduino microcontroller. The LDR is connected to the A0 of your Arduino and it checks the intensity of light around (day or in well-lit rooms). When the system detects a light level above a set threshold and determines that it is daylight, it switches itself off and disables the lighting circuit, to prevent wasted energy.

When ambient light is decreased in the night time, LDR senses and goes to working mode. This is the time, when an ultrasonic sensor has to perform to detect near motion e.g. human, pedestrians, cyclist, car. It is the streetlight which is in fact a LED next to these sensors, as both are interconnected and they have a sensor that sends a signal whenever movement is detected within the immediate range of its network for control. If no movement is detected in the span of a few quick setup times, then it shuts off without anyone else, which means you do not waste excessive power but that you still have it when and where you need this to feel.

This thing was designed such that the streetlight would simply remain switching off during the day, even with a movement (via LDR sensor). Then it would come on at night, and turn on if it saw any motion (via ultrasonic sensor). In conjunction with real-time motion detection these all provide context awareness to your automation and make it practically zero energy wasted while keeping things humming along while the end user is at work, school, out doing errands etc.

Code Logic (Simplified):

Start

└─► *Read LDR value* → *Check if it's dark* (*light* ≤ 400)

└─► *If YES*:

└─► *Trigger ultrasonic* → *Measure distance*

└─► *If object is close* (*distance* ≤ 5 cm):

└─► *Turn ON LED*

└─► *Else*:

└─► *Turn OFF LED*

└─► *Else* (*It's bright*):

└─► *Keep LED OFF*

Repeat

This Logic ensures the smooth operation of Automatic Street Light that turns ON only at dark when somebody is nearby reducing unnecessary power wastage.

8. Results and Discussion

The system was tested in different lighting and movement conditions. During the day, the lights just dimmed to off, even when there is motion. In the dark, lights were switched on only if some motion was detected. The system was found to be fast (in the order of milliseconds) and efficient (in terms of both efficiency and effectiveness). Power saving estimated to more than 60% compared to conventional lighting in simulated conditions.

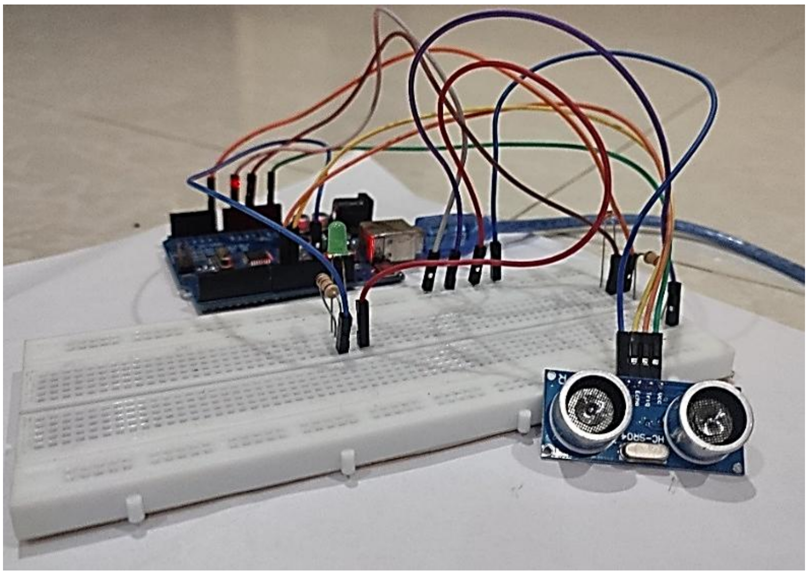

Fig.5: Our Setup simulating the Automatic Street Light

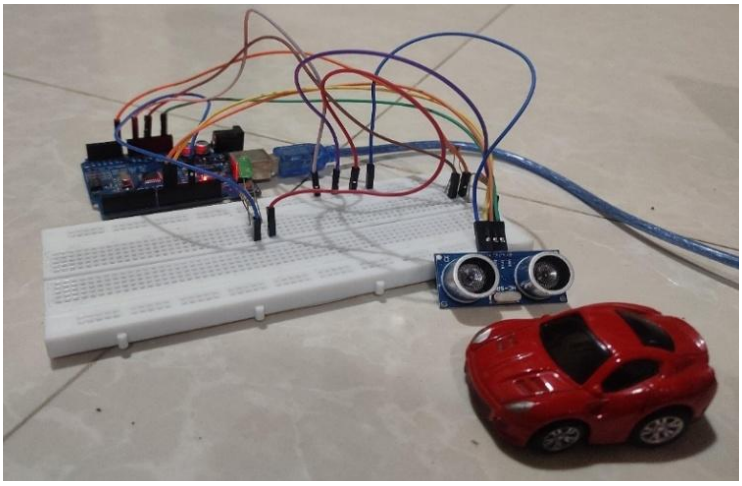

Fig.6: The LED is not glowing even when there is an object Infront of the sensor.

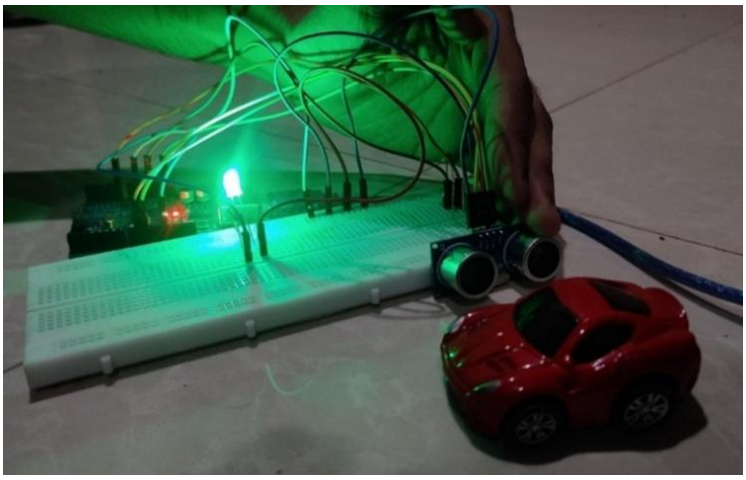

Fig.7: The LED is glowing only when there is motion alongside sufficient darkness.

9. Swot Analysis

Table 1: Strengths and Weaknesses

Strengths	**Weaknesses**
Energy-efficient	Limited detection range
Low-cost implementation	Weather sensitivity (outdoors)
Simple & scalable design	Requires regular calibration

Table 2: Opportunities and Threats

Opportunities	**Threats**
Smart city integration	Sensor malfunction or damage
Solar-powered expansion	Technological obsolescence

10. Real-Time Workflow Example

As the sun sets towards the horizon in a hushed residential street, evening descends on suburbia and shadows begin to cover no longer lit areas. A change in light level is detected by a Light Dependent Resistor (LDR) and continuity checks are made every 5s to make sure the Arduino never mistakes one ambient light level for another. The smart street light system was then placed in awake mode after the LDR reading was lower than a predetermined value, suggesting that it is dark enough to have lighting if motion happened. The street lights are OFF normally in order to conserve energy; they turn ON when motion is detected. Out on the sidewalk, a pedestrian is picked up by an ultrasonic sensor installed on the nearest lamp post. The ultrasonic sensor sends sound waves and calculates the time taken by the waves to reflect back after striking an object. The change in distance triggers the Arduino-controlled system to interpret it as motion.

Upon arrival the Arduino reads this input along with the level of light from the LDR and sees that both states, darkness and motion, are true. After that, the system lights up the appropriate streetlight to make sure that the pedestrian is not only visible to drivers but also feels safe and comfortable. Once she leaves and does not detect any more movement for a set period (for example 30 seconds), the system switches off the light automatically. This smart behavior not only lowers useless power consumption but also makes the lights work longer. This cycles continuously, adding a level of energy efficiency and real-time responsiveness that other connected lighting systems fail to address.

Fig. 8: Working of the Automatic Street Light.

11. Future Scope

In future, initiative may be taken to make the circuitry compatible with solar panels to achieve off-grid use including IoT modules (Wi-Fi or LoRa for example) for central controls. Moreover, scaling to entire smart-lighting grids across cities and campuses can be emphasized with adaptive brightness based on traffic density. The above facts are pictorially described below.

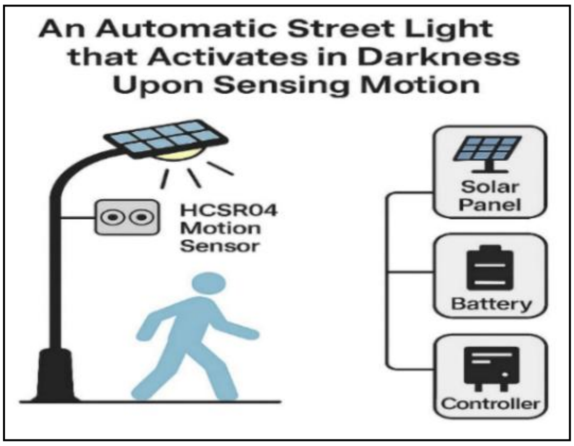

Fig. 9: Solar Panel as Power Source of the Automatic Street Light.

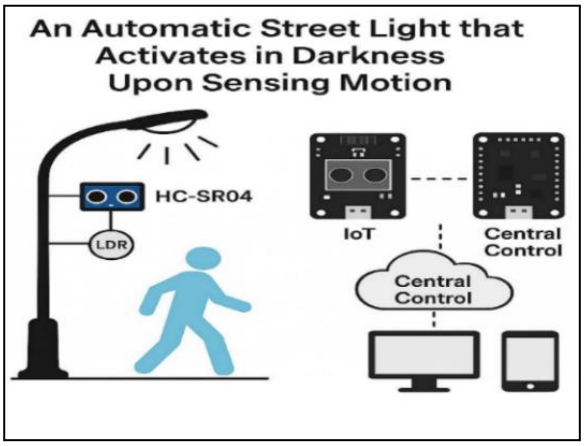

Fig. 10: Integration of IoT in the Automatic Street Light.

Fig. 11: Automatic Street Light along the Campus perimeter.

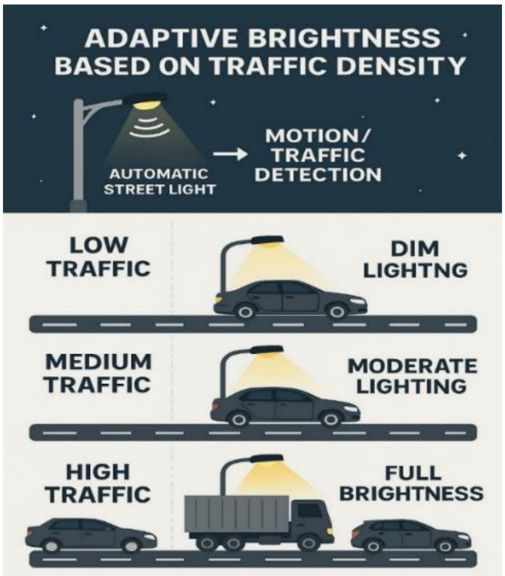

Fig. 12: Adaptive Brightness by Automatic Street Light based on Traffic Density.

12. Conclusion

This design successfully implements an automated, intelligent and power durable street light system by utilizing simple electronics components and microcontroller-based controlling. It is an example of how small-scale solutions can result in big energy savings and increased safety. This dynamic system is scalable, environmentally friendly, and a practical solution for both smart cities and campuses.

13. Acknowledgement

The authors place on records their acknowledgement to Mr. Noman Hanif Barbhuiya, Ph.D. Scholar, IIT, Gandhinagar for his valuable contribution and insights. This work has been done

as a part of UG dissertation of CBCS Even Semester examination 2025. Images corresponding to fig.1, fig. 2, fig. 8, fig. 9, fig. 10, fig. 11 and fig. 12 was generated in ChatGPT (GPT 4.1)".

References

1. M. Geddes, Arduino Project Handbook: 25 Practical Projects to Get You Started. San Francisco, CA: No Starch Press, 2016.
2. SparkFun Electronics, "HC-SR04 Ultrasonic Distance Sensor Datasheet," [Online]. Available: https://cdn.sparkfun.com/datasheets/Sensors/Proximity/HCSR04.pdf.
3. D. Patranabis, Sensors and Transducers, 2nd edition, New Delhi, India: PHI Learning Pvt. Ltd., 2013.
4. M. Castro, A. J. Jara and A. F. Skarmeta, “Smart lighting solutions for smart cities,” in Proc. 27th International Conference on Advanced Information Networking and Applications Workshops (WAINA), Barcelona, Spain, Mar. 2013, pp. 1374–1379, doi: 10.1109/WAINA.2013.254.
5. Autodesk, "Tinkercad," [Online]. Available: https://www.tinkercad.com.