HOSPITAL ROOM DISINFECTION ROBOT USING UV LIGHT

[1]A. Abhinay, [2]B. Mokshitha, [3]B. Sanjana, [4]M. Vasanthika, [5]Rambabu Pemula

[1]B.Tech Student, [2]B.Tech Student, [3]B.Tech Student, [4]B.Tech Student, [5]Associate Professor
[1]Department of Information Technology,
[1]Vidya Jyothi Institute of Technology, Hyderabad, India

Abstract : Hospital-acquired infections (HAIs) are a serious concern in healthcare facilities. They increase the risk of illness for both patients and healthcare workers. Traditional cleaning methods that use chemical disinfectants take a lot of time and may not fully remove harmful microorganisms from surfaces that people touch frequently.
This paper presents a Bluetooth-controlled Hospital Room Disinfection Robot that uses UV-C light and is based on the Arduino Uno microcontroller. The system can be controlled remotely through voice commands via an Android smartphone connected with an HC-05 Bluetooth module. An L298 motor driver manages the robot's movement, and an HC-SR04 ultrasonic sensor detects obstacles to ensure safe navigation. A relay module is used to turn the UV-C lamp on and off for effective surface disinfection while reducing direct human exposure to contaminated areas.
The proposed robot offers a low-cost, portable, and user-friendly solution for hospitals, clinics, laboratories, and isolation wards, where regular sterilization is crucial. Experimental tests showed reliable wireless communication, smooth movement, accurate obstacle detection, and effective control of the UV lamp. By minimizing manual intervention and improving disinfection efficiency, the system helps enhance infection control and create safer healthcare environments. Future enhancements may include self-navigation, IoT-based monitoring, and AI-assisted path planning for better performance and coverage.

***IndexTerms* - Component,formatting,style,styling,insert.**

I.INTRODUCTION

Healthcare-Associated Infections (HAIs) remain a major concern in hospitals and healthcare facilities around the world. These infections increase patient illness and death rates, lead to longer hospital stays, and raise healthcare costs. Contaminated surfaces and medical equipment are key sources of pathogen spread. Therefore, effective cleaning of the environment is crucial for preventing and controlling infections. While chemical disinfectants are common, they often require a lot of manual effort, take time, and can leave harmful chemical residues. Additionally, manual cleaning may miss hidden or frequently touched surfaces, reducing the overall effectiveness of disinfection [1], [2].

Ultraviolet-C (UV-C) light has proven to be an effective, chemical-free, and contactless disinfection method. Operating at wavelengths from 200 to 280 nm, UV-C radiation destroys the DNA and RNA of microorganisms, making it effective against bacteria, viruses, fungi, and other harmful pathogens. Due to its high sterilization efficiency and lack of chemical residues,

UV-C technology has gained attention for use in hospitals, labs, public transport, and other public spaces [3], [4]. Recent studies show that robotic UV-C systems can significantly enhance surface disinfection while lowering healthcare workers' exposure to contaminated areas [5].

Combining mobile robotics with UV-C technology has improved the effectiveness of automated disinfection systems. Mobile UV-C robots can navigate indoor spaces, disinfect multiple surfaces, and reduce the need for human intervention. Many advanced robotic systems use autonomous navigation, environmental mapping, and optimized path-planning to maximize UVC coverage and cut down disinfection time [6], [7]. However, many of these systems depend on costly hardware, such as LiDAR sensors, SLAM algorithms, artificial intelligence, and high-end controllers. This makes them hard to implement in small hospitals and underfunded healthcare facilities [8].

To tackle these issues, researchers have suggested several budget-friendly robotic disinfection solutions. The UVC-PURGE system introduced a low-cost semiautonomous UV-C robot that achieves substantial microbial reduction while being user-friendly [1]. Similarly, the Automated Robot with UV-C Sterilizer showed that an Arduino-based platform with ultrasonic sensors and wireless communication could offer an affordable option for disinfecting public places [9]. Other studies highlighted the need for obstacle detection and human safety features to avoid accidental UV-C exposure during robot operation [4], [8].

Despite these advances, current UV-C disinfection robots still encounter difficulties, such as high costs, complex navigation, limited affordability, and inadequate safety features. These challenges hinder their practical use, especially in small hospitals, clinics, and schools [8], [10]. Thus, there is a growing demand for a simple, reliable, and low-cost robotic disinfection system that can effectively sanitize indoor spaces while ensuring safe operation.

In this paper, we introduce a blue tooth-controlled Hospital Room Disinfection Robot that uses UV Light and is based on the Arduino Uno microcontroller. This system combines an HC-05 Bluetooth module for wireless voice command control, an L298 motor driver for movement, an HC-SR04 ultrasonic sensor for obstacle detection and collision avoidance, and a relay-controlled

UV lamp for contactless surface sterilization. Unlike expensive autonomous robots, this design focuses on affordability, ease of use, and practical implementation with readily available components. The robot enables remote-controlled disinfection, reduces direct human exposure to contaminated areas, and provides a cost-effective solution for hospitals, clinics, labs, and schools.

II. LITERATURE SURVEY

Zaman et al.[1] developed UVC-PURGE, a semi-autonomous UV-C robot designed to provide hospitals and public spaces with an affordable solution to fight COVID-19. Instead of using expensive parts, the team focused on keeping costs low while ensuring high sterilization quality. They highlighted the downsides of chemical disinfectants, including fumes, residue, and the labor required, advocating for UV-C as a better option due to its low maintenance, quick results, and eco-friendly nature. The robot could navigate semi-autonomously and adjusted its UV-C dosage automatically. In tests, it significantly reduced microbial counts, and users found it easy to operate. The takeaway is that budget-friendly UV-C robots could genuinely assist developing countries and overburdened healthcare systems in increasing disinfection efforts.

Füszl and colleagues[2] used a practical approach, testing a UV-C robot as part of standard hospital cleaning instead of in a controlled lab environment. They measured microbial levels in outpatient clinics after manual cleaning and after the robot's UV-C treatment. The robot noticeably reduced contamination. However, the study acknowledged some challenges: the robot had difficulty navigating independently, frequently got interrupted by people or moving objects, and was not very effective against tougher organisms like Candida auris. Their conclusion was balanced: UVC robots are helpful, but they are not yet ready to fully replace or integrate into routine hospital workflows.

Martínez de Alba and the team[3] compared standard UV-C robots with those that also generated ozone, testing both against various bacteria, fungi, and yeasts. UV-C alone effectively killed microorganisms, but adding ozone made a significant difference in areas where UV-C light could not reach directly, such as shadowed corners and surfaces. The researchers presented UV-C as a truly chemical-free option for cleaning air and surfaces, arguing that combining it with cumulative irradiation technology could be an effective tool for controlling outbreaks in hospitals and crowded public places.

Bratu and colleagues[4] created the RoboCoV Cleaner with safety as the primary design focus since UV-C light can harm skin and eyes if people are exposed. Their robot used a combination of PIR sensors and AI-driven object detection through a 360-degree camera to reliably identify humans, reaching over 99% detection accuracy in various conditions. Besides disinfecting, it could also recognize objects and adjust its disinfection method accordingly. They emphasized that as these robots become smarter, sensor integration and AI are essential; they are what make autonomous UV-C systems safe enough to deploy around people.

Casini and the team[5] examined the effects of adding a UV-C robot as an extra step after regular hospital cleaning, focusing on high-touch surfaces in critical care areas. They swabbed surfaces before and after the robot operated and found that contamination dropped significantly compared to manual cleaning alone. Their main point was that UV-C robots are not just a nice addition; they significantly reduce healthcare-associated infections and help eliminate some of the human error that can occur in manual cleaning routines.

Tiseni and colleagues[6] addressed a different aspect: the robot's movement. They measured the actual UV-C dose delivered as their robot moved through indoor spaces. They used a genetic algorithm along with an artificial potential field to plan better paths that covered more area with UV dose while taking less time. The optimized routes clearly outperformed the standard back-and-forth patterns that most robots use. Their conclusion highlights a recurring theme: it's not just about having UV-C light; it's about how smartly the robot moves through a room.

Perminov and his team[7] developed "UltraBot" specifically to disinfect indoor spaces without using chemicals or sprays. The paper details its mechanical build, control systems, how it locates itself, and how it plans optimal irradiation paths. In testing, it achieved a 94% reduction in total bacterial count from 2.8 meters away after ten minutes of exposure, which is a strong result. They also emphasized the importance of reliable navigation and obstacle avoidance in constantly changing environments like hospital corridors or offices. In short, robots like this reduce disinfection time and, importantly, protect people from pathogens and harsh chemicals.

Pfleger and colleagues[8] reviewed 96 studies on UV-C disinfection robots, showing how their use surged in hospitals, schools, airports, and public transit after
COVID emerged. Instead of just summarizing, they found common issues in the field, such as getting the UV dose correct, navigation and mapping problems, shadow effects blocking light from reaching all surfaces, and ensuring human safety during operation. They also suggested a new way to classify these robots based on their technological maturity and operational capability. Their overall judgment is that while the potential exists, many systems still struggle with navigation, safety, and precise dosing in real-world applications.

Choudhary and his team[9] focused on public spaces by creating an automated robot with a UV-C sterilizer designed for large indoor areas. They explained why regular disinfection became essential after COVID, as diseases can spread easily through both air and surfaces in busy environments. After reviewing previous robotic disinfection systems, they argued for maintaining cost-effectiveness without compromising performance. Their conclusion is that robots like this significantly relieve human workers while ensuring that high-traffic areas like airports, hospitals, and malls are consistently disinfected.

Together, these studies present a strong argument that UV-C robotic disinfection really enhances hygiene in hospitals and public spaces. The field has clearly advanced beyond just questioning if UV-C works; researchers are now improving autonomous navigation, smarter path planning, safety systems, and better sensing to make these robots more reliable and practical. However, several issues persist across almost every paper, such as shadow effects blocking light from certain surfaces, achieving the correct UV dose, navigating unpredictable real-world environments, and ensuring safety around people. Overall, UV-C disinfection robots appear to be a solid, chemical-free, contactless solution that still has room for improvement before becoming fully effective for widespread use in healthcare and public sanitation.

III. EXISTING METHODS

Several researchers have proposed robotic disinfection systems to lower healthcareassociated infections by combining ultraviolet (UV-C) technology with mobile robotics. Existing systems vary in navigation, safety features, automation level, and disinfection effectiveness.

Zaman et al. proposed UVC-PURGE, a cost-effective semi-autonomous UV-C
disinfection robot meant to reduce microbial contamination in healthcare settings. The system used UV-C light for surface sterilization and showed a significant drop in microbes while being more affordable than commercial options. However, it still needed operator supervision and did not provide fully autonomous navigation [1].

Astrid et al. tested a UV-C disinfection robot in a real hospital setting. Their study found that pairing UV-C light with traditional cleaning greatly decreased microbial growth on hospital surfaces. However, the robot needed trained personnel to operate it, and a single UV-C cycle did not eliminate highly resistant microorganisms, which limited its practical use [2].

Martínez de Alba et al. looked into robotic disinfection using UV-C and UV-C

combined with ozone generation. Their results showed effective removal of bacteria, fungi, and viruses while reducing the need for chemical disinfectants. However, generating ozone requires careful control since too much exposure can cause safety issues [3].

Perminov et al. introduced UltraBot, an autonomous indoor UV-C disinfection robot that can localize itself and plan optimal paths. Experimental results revealed a 94% reduction in total bacterial count after UV-C exposure. Although the robot achieved high disinfection efficiency, it relied on complex localization and navigation techniques, raising implementation difficulty and cost [4].

Casini et al. suggested an improved hospital cleaning method by combining UV-C robots with traditional cleaning procedures. Their findings showed that UV-C treatment significantly cut contamination on hightouch surfaces compared to manual cleaning alone. However, the robot was mainly meant to enhance existing cleaning practices instead of replacing them [5].

Bratu et al. developed the RoboCoV Cleaner, an autonomous UV-C robot equipped with AIbased human detection, PIR sensors, and multiple safety features. The system achieved high accuracy in detecting humans and improved operational safety. Despite its advanced technology, the addition of AI vision and various sensors made the system more complex and costly
[6].

Choudhary et al. presented an Arduinobased Automated Robot with UV-C
Sterilizer for disinfecting public spaces. The robot used Bluetooth communication, ultrasonic sensors, and UV-C light to offer a budget-friendly and practical solution. However, its functionality mainly relied on manual control and had limited autonomous capabilities [7].

Mehta et al. reviewed the development of UV disinfection robots, highlighting the benefits of robotic UV-C systems compared to traditional chemical disinfection. The review also pointed out several ongoing challenges, such as delivering the right UV dose, navigation, shadow effects, and human safety, which limit broader adoption
[8].

Pfleger et al. conducted a thorough systematic review of 96 studies on UV-C disinfection robots. Their analysis found that many existing robots lack accurate UV dose measurement, effective navigation, and sufficient safety features. The study stressed the need for affordable, reliable, and safe UV-C robotic systems suitable for real-world use [9].

Based on the analysis of current methods, it is clear that most UV-C disinfection robots either depend on expensive autonomous hardware or require significant human intervention. Therefore, this work suggests a Bluetooth-controlled Hospital Room Disinfection Robot using Arduino Uno, HC-05 Bluetooth module, HC-SR04 ultrasonic sensor, L298 motor driver, and relay-controlled UV light to provide a lowcost, user-friendly, and reliable disinfection solution while ensuring safe operation [1]–
[9].

IV. PROPOSED METHOD

The proposed system is a Bluetoothcontrolled Hospital Room Disinfection Robot that uses ultraviolet (UV) light to clean hospital rooms while reducing human exposure to infectious areas. The robot is built around an Arduino Uno microcontroller, which serves as the main control unit and coordinates all hardware components. The system includes an HC05 Bluetooth module, an HC-SR04 ultrasonic sensor, an L298 motor driver, DC motors, a relay module, a UV lamp, and separate power supplies for the controller and motors.

Users control the robot with an Android smartphone using voice commands. These commands are sent wirelessly through the Bluetooth module to the Arduino Uno. The Arduino reads the commands and sends the right control signals to the L298 motor driver, allowing the robot to move forward, backward, left, right, or stop. Meanwhile, the relay module manages the UV lamp, enabling it to be turned ON or OFF remotely for room disinfection.

For improved safety, the robot has an HCSR04 ultrasonic sensor for detecting obstacles. The sensor constantly measures the distance between the robot and nearby objects. If it detects an obstacle within a set distance (20 cm), the Arduino stops the motors immediately to prevent collisions and ensure safe operation. The control system supports wireless communication, effective movement control, UV light operation, and obstacle avoidance in a compact, costeffective setup.

This system provides several benefits over traditional manual disinfection methods, such as less human exposure to dangerous germs, wireless operation, easy implementation, and low cost. It is therefore suitable for hospitals, clinics, laboratories, and other places needing regular surface cleaning.

WORKING—

The proposed Hospital Room Disinfection Robot's overall design is shown in Fig. 1, while Fig. 2 displays the full hardware circuit setup. In Fig. 1, the Arduino Uno serves as the main controller and connects with the HC-05 Bluetooth module, HCSR04 ultrasonic sensor, L298 motor driver, relay module, DC motors, and UV lamp. Fig. 2 provides detailed circuit connections among these components.

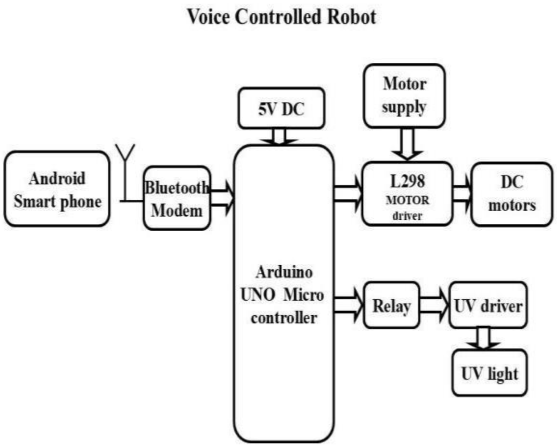

Fig. 1. Block diagram of the proposed Hospital Room Disinfection Robot using UV Light.

First, the user issues a voice command through an Android smartphone app. The app transforms the voice command into a Bluetooth signal and sends it to the HC-05 Bluetooth module. The Bluetooth module then transmits the command to the Arduino Uno via serial (UART) communication. The Arduino interprets the command and decides what action to take.
For movement commands like Forward (F), Backward (B), Left (L), Right (R), and Stop (S), the Arduino sends the right control signals to the L298 motor driver. This driver powers the two DC motors in the chosen direction. For the UV ON (U) and UV OFF (u) commands, the Arduino manages the relay module to turn the UV lamp ON or OFF wirelessly, allowing for contactless surface disinfection. The relay separates the low-voltage control circuit from the UV lamp's power supply, ensuring safe operation.

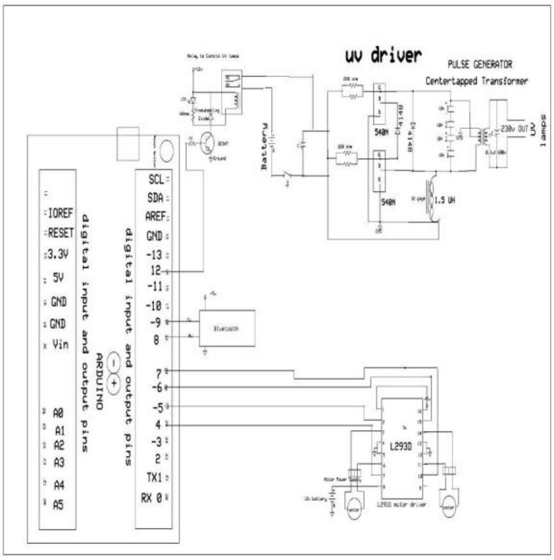

Fig. 2. Circuit diagram of the proposed Hospital Room Disinfection Robot using UV Light.

To boost safety during movement, the HCSR04 ultrasonic sensor constantly checks the distance between the robot and nearby obstacles. If an object is within the set distance of 20 cm, the Arduino swiftly stops both motors to avoid collisions. Once the obstacle is cleared, the robot continues its task based on the Bluetooth commands it receives. This obstacle detection feature enhances the system's reliability and safety.

INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD)
© 2026 IJNRD | Volume 11, Issue 7, July 2026 | ISSN: 2456-4184 | IJNRD.ORG

The full operational flow of the system can be summed up as follows:
Android Smartphone → HC-05 Bluetooth Module → Arduino Uno → L298 Motor Driver →
DC Motors

Arduino Uno → Relay Module → UV Lamp

HC-SR04 Ultrasonic Sensor → Arduino Uno → Automatic Stop (Obstacle Detection)

The combination of wireless communication, embedded control, UV sterilization, and automatic obstacle detection creates a low-cost, user-friendly, and effective robotic system for hospital rooms, clinics, laboratories, and other healthcare settings that need regular disinfection.

V. RESULTS AND DISCUSSION

The proposed Bluetooth-controlled Hospital Room Disinfection Robot was designed, built, and tested successfully. The prototype includes an Arduino Uno, HC-05 Bluetooth module, HCSR04 ultrasonic sensor, L298 motor driver, relay module, DC motors, and a UV lamp in a single embedded system. Experimental tests showed that all hardware components worked correctly and communicated without significant delays.

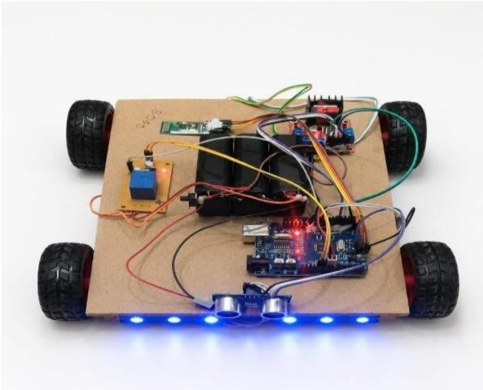

Fig 3: Final Output

The Bluetooth module set up a wireless connection with an Android smartphone, allowing for voice-command control of the robot. The robot carried out movement commands accurately, including Forward, Backward, Left, Right, and Stop. The relay module turned the UV lamp ON and OFF based on user commands, enabling remote disinfection.
The HC-SR04 ultrasonic sensor monitored the surroundings continuously during operation. When it detected an obstacle within a threshold distance of 20 cm, the Arduino stopped the robot automatically, preventing collisions and enhancing safety.
The obstacle detection worked consistently in repeated tests.
Performance evaluations showed that the robot maintained stable Bluetooth communication up to about 10 meters indoors. The movement control was smooth, and the UV lamp responded immediately when switched. These findings indicate that the system offers an affordable and reliable option for contactless disinfection in hospitals, clinics, laboratories, and similar indoor spaces. Although the robot operates under
Bluetooth control, it significantly reduces direct human exposure during sanitization and ensures safe operation through obstacle detection.

Table I. Performance Analysis

Feature	Result
Bluetooth Communication	Successful
Voice Command Control	Successful
Robot Movement	Successful
UV Lamp Control	Successful
Obstacle Detection	Successful
Automatic Stop Function	Successful
Overall System Performance	Satisfactory

VI. CONCLUSION

This paper presented a Bluetooth-controlled Hospital Room Disinfection Robot that uses UV Light and the Arduino Uno microcontroller. The proposed system successfully combines wireless Bluetooth communication, voice-command control, UV lamp switching, movement using DC motors, and ultrasonic obstacle detection into a compact and affordable robotic platform. Experimental results showed reliable robot navigation, effective remote operation, and automatic obstacle avoidance. This approach reduces direct human exposure during the disinfection process. Compared to traditional manual sanitization methods, the proposed system offers a safer, user-friendly, and costeffective solution for hospitals, clinics, laboratories, and other healthcare settings. In the future, the system can be improved by adding autonomous navigation, IoTbased monitoring, AI-assisted path planning, and better human detection methods to boost disinfection efficiency, coverage, and operational safety.

REFERENCES

[1] A. Zaman et al., "UVC-PURGE: A Novel Cost-Effective Disinfection Robot for Combating COVID-19 Pandemic," IEEE Access, vol. 10, pp. xxxx-xxxx, 2022.

[2] A. Füszl et al., "The Use of a UV-C

Disinfection Robot in the Routine Cleaning Process: A Field Study in an Academic Hospital," Antimicrobial Resistance & Infection Control, vol. 10, no. 1, 2021.

[3] M. Martínez de Alba et al., "Microbiological Evaluation of the Disinfecting Potential of UV-C and UVC Plus Ozone Generating Robots," Microorganisms, vol. 9, no. 8, 2021.

[4] C. Bratu et al., "RoboCoV Cleaner: An Indoor Autonomous UV-C Disinfection Robot with Advanced Dual-Safety Systems," Sensors, vol. 24, no. xx, 2024.

[5] B. Casini et al., "Implementation of an Environmental Cleaning Protocol in Hospital Critical Areas Using a UV-C Disinfection Robot," International Journal of Environmental Research and Public Health, vol. 20, no. xx, 2023.

[6] K. Tiseni et al., "UV-C Mobile Robots with Optimized Path Planning Algorithm Design and On-Field Measurements to Improve Surface Disinfection Against SARS-CoV-2," IEEE Robotics & Automation Magazine, vol. 28, no. xx, pp. xx-xx, 2021.

[7] D. Perminov et al., "UltraBot: Autonomous Mobile Robot for Indoor UV-C Disinfection," Proceedings of the IEEE International Conference on Automation Science and Engineering (CASE), 2021.

[8] P. Pfleger et al., "UV-C Disinfection Robots: A Systematic Review," Journal of Field Robotics, vol. xx, no. xx, 2025.

[9] A. Choudhary et al., "Automated Robot with UV-C Sterilizer for Disinfection of Public Places," Proceedings of the IEEE SPARC Conference, 2024.

[10] Krishna Kumar, Dr. P. Rambabu (December-2024). IoT Based Air Pollution Monitoring System. INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT, 9(12), c4-c6. https://ijnrd.org/papers/IJNRD2412202.pdf

[11] Rambabu Pemula, Paiyala Hyndhav, K. Sai Loknath Naik, K. Bharath Chary, T. Gokul Nitish, "Development of a Voice - Controlled Robot with Facial Recognition, Inspired by WALL-E", International Research Journal of Modernization in Engineering Technology and Science, Volume:07, Issue:04, April-2025, pp 11477-11480.

[12] R Pemula, A Obulesu, P Hyndhav, KSL Naik, KB Chary, TG Nitish, "Autonomous AI Robot: Environmental Awareness using LiDAR with ROS", Grenze International Journal of Engineering and Technology 11 (2), 5967-5973

[13] R Pemula, A Obulesu, T Srija, SM Shireen, D Sriya, NS Sumeet "Automated Road Damage Detection using UAV Images and Deep Learning Techniques" Grenze International Journal of Engineering and Technology 11 (2), 5911-5917