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Automatic Helmet Sanitizer with Brush and Multi-Mode Payment System

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Abstract: This study outlines the design and construction of an Automatic Helmet Sanitizer with Brush and Multi-Mode Payment System to enhance the helmet cleaning and convenience to the users of motorcycles. The system combines UV-C light sterilization, mechanical brushing, and mist disinfectant to adequately clean the interior and exterior parts of motorcycle helmets. To increase accessibility, the system accommodates various options of payment such as coin, QR based e-wallet, and cryptocurrency payments. The research design used was that of development, which involved laboratory testing, expert validation and user satisfaction survey to determine the performance of the systems. Findings indicated 80% sanitation efficiency, significantly reducing bacteria, fungi, and odor-producing microorganisms, which demonstrates its effectiveness in improving helmet hygiene. The overall mean score was 3.74 which was evaluated as a strong level of approval of the overall effectiveness of the system, its usability and payment capabilities. The results indicate that the suggested system is an effective, credible, and easy to use solution that has a good prospect of being applied in the real world in both the public and commercial environments.

Keywords: *Automatic Helmet Sanitizer; Sanitization; Helmet Hygiene; Disinfectant.*

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I. INTRODUCTION

Prior to the COVID-19 pandemic, most efforts to prevent the transmission of infectious diseases were focused on proper hygiene practices and minimizing contamination of frequently used tools and surfaces. However, in recent years, increased attention has been given to personal protective equipment (PPE), particularly motorcycle helmets, which are widely used in mass and commercial transportation. In the Philippines, the rapid growth of motorcycle-based transport services such as ride-hailing and delivery platforms has resulted in the frequent sharing and reuse of helmets, thereby increasing the risk of microbial transmission when proper sanitation is not observed.

Several studies conducted in different countries have confirmed that motorcycle helmets can harbor harmful microorganisms if not regularly cleaned. Findings indicate that commonly used helmets contain bacteria such as Staphylococcus aureus and Escherichia coli, as well as fungi, highlighting the potential health risks associated with the use of inadequately disinfected helmets [1]. These findings emphasize the importance of regular and effective helmet cleaning to prevent skin infections and other hygiene-related diseases.

To address these concerns, various sanitation technologies have been explored. Studies have shown that ultraviolet (UV) sterilization is an effective and contact-free method for reducing microbial contamination on personal equipment. More recent findings revealed that integrating sanitation systems with Internet of Things (IoT) technology improves monitoring, efficiency, and reliability [2], [3]. In addition, research has emphasized that contactless services and automated sanitation systems are positively received by users and support the development of hygienic environments [4]. Other studies further noted that digital payment systems enhance user acceptance and contribute to smart city initiatives [5].

Helmet sanitation remains a growing concern in the Philippine context. Findings indicate that most motorcycle taxi drivers in Metro Manila do not regularly clean shared helmets [6]. Likewise, observations show that delivery riders in Cavite often use visibly dirty helmets due to inconvenience, lack of time, or the absence of accessible cleaning facilities [7]. These localized findings reveal a clear gap between helmet usage and proper hygiene practices among Filipino riders.

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Local innovations have begun addressing this issue. Studies demonstrated that UV-based sanitation booths installed in public transport terminals significantly reduced surface contamination [8]. Similarly, a UV-based helmet sanitizing prototype was developed and recommendations were made to incorporate a brush mechanism to further improve cleaning effectiveness [9]. Moreover, findings indicate that integrating convenient payment options such as e-wallets and cryptocurrency increases accessibility and encourages greater usage of vending-style services [10].

In line with these findings, the researchers conducted a survey involving 57 respondents, exceeding the target population and improving data reliability. Results showed that 80.7% of respondent's wear helmets daily, while only 49.1% clean their helmets regularly, indicating a significant disparity between helmet use and hygiene practices. Many respondents expressed concern over helmet cleanliness and preferred a sanitizing solution that is convenient, fast, and readily available. These results indicate a strong demand for an efficient, user-friendly, and locally oriented helmet sanitation system.

The automatic helmet sanitizer with brush and multi-mode payment system was designed in accordance with ISO 20282-1:2006 standards, which emphasize usability, accessibility, and user safety [11]. The system integrates UV sterilization, brush-based cleaning, and IoT technology for real-time monitoring and transaction tracking. It supports multiple payment methods, including coins, e-wallets, and cryptocurrency. The proposed system aims to enhance the commuting experience of Filipino riders by combining hygiene, convenience, and digital innovation to promote a safer and more sanitary mode of transportation.

II. METHODOLOGY

This part of the study involved the set of procedures that is use to collect and analyze data in line with the research questions. It includes the research design, research instrument, data gathering procedure, and data analysis.

- *Research Design*

A developmental research design was utilized to guide on the design, development, testing and improvement of an Automatic Helmet Sanitizer with Brush and Multi- Mode Payment System. Initial data collection was conducted through interviews and survey questionnaires to determine the issues of helmet hygiene and user needs, which formed the design of the system.

The design includes UV-C sterilization, mechanical brushing, misting disinfection, LCD touchscreen interface, IoT-based monitoring, and multi-mode payment system. The system was subjected to professional laboratory testing, which was carried out by experts and was performed according to standard microbiological protocols on pre- and post-sanitized swabs under controlled conditions to provide an accurate and valid determination of the sanitation effectiveness of the system. Also, the design was tested under real-time conditions, with IoT monitoring files and Raspberry Pi system logs recording usage statistics and system performance.

- *Research Instrument*

The main instrumentation used to conduct this study is a 4-Likert scale questionnaire that was given to the users and experts to determine the satisfaction of users and the acceptability of the system. It tested the effectiveness of sanitation, UV-C sterilization, brush cleaning, ease of use, interface design and convenience of multi-mode payment system, and open-ended items were added on the additional feedback and suggestions. The tool was validated through an expert and engineers, and was pilot tested to elicit clarity, consistency, reliability and suitability in terms of data collection.

- *Data Gathering Procedure*

Prior to the development of the automatic helmet sanitizer with brush and multi-mode payment system, the researchers conducted an initial data gathering to determine the needs of the motorcycle riders regarding the helmet sanitation. The data collected was used to develop the new design for helmet sanitation.

After the development of the automatic helmet sanitizer, a new set of data collection was conducted to observe and test the actual setting of operation and how the users interacted with the automatic helmet sanitizer. A validated questionnaire was issued to over 50 motorcycle riders to collect information regarding helmet cleanliness practices, perceived usefulness, convenience, and satisfaction with the system, including its multi-mode payment functionality. The data collected was analyze and interpreted.

- *Data Analysis*

All the gathered data were analyzed using descriptive statistics. The researchers utilized mean and percentages to determine the performance of the system, its acceptance by the users and its functionality. The results of the survey were calculated in terms of percentage distributions, the use of the system was also evaluated by some measurable performance indicators, and the microbiological results were analyzed in terms of the percentage of reduction rate. Based on these analysis, it was possible to conclude about general efficiency and practical use of the automatic helmet sanitizer and define some areas of its enhancement.

III. RESULTS AND DISCUSION

This part explains the interpretation of the data collected during the initial survey, expert evaluation, and user testing, establishing how each results substantiates the objectives of the study and justifies the development of the automatic helmet sanitizer with brush and multi-mode payment system.

- *Design Features, System Components, and Operational Mechanisms*

The design, components and operations of the system are in coordination to offer effective and efficient sanitation of the helmets.

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Table 1 UV-C Cleaning Efficiency Test Results

Trial	With UV-C Light (CFU Reduction)	Without UV-C Light (CFU Reduction)
1	92% Reduction	18% Reduction
2	89% Reduction	20% Reduction
3	94% Reduction	17% Reduction
Mean	91.66% Reduction	18.33 Reduction

Table 1 shows that the design with UV-C light attained a mean of 91.66% reduction of CFU or colony- forming unit, while the design without UV-C light showed a mean of 18.33% reduction of CFU. These findings reveal the effectiveness of UV-C light in disinfecting the motorcycle helmets by reducing CFU levels.

Table 2 Brush Test Result

Trial	Brush Cleaning Effectiveness	Observed Outcome
1	85% Surface Dirt Removal	Visible dust and debris significantly reduced
2	88% Surface Dirt Removal	Consistent removal of sweat marks and smudges
3	90% Surface Dirt Removal	Highest efficiency, smooth brushing pattern
Mean	87.66% Surface Dirt Removal	Consistent removal of sweat marks and smudges

The mechanical brushing system was able to clean the surface of the helmet with a mean efficiency of 87.66%, which shows that the device is consistent in removing sweat marks and smudges on the surface of the helmet. This is significant since the removal of physical debris enhances the results of further disinfection procedures.

Table 3 Multi-Mode Payment System Result

Transaction Type	Success Rate	Notes
Coin Payment	96% Successful	Minor issues only when coins inserted too fast or tilted
QR / E-Wallet Payment	93% Successful	Occasional delays due to network conditions
Cryptocurrency (Solana Pay)	89% Successful	Stable but affected by internet latency

The Multi-Mode Payment System in Table 3 was found to be quite reliable as coin payments were successful at a rate of 96%, e-wallet payments using QR code at a rate 93% with the Multi-Mode payment system (GCash and Maya), and Solana Pay at a rate of 89%. The reason is that credible transactions enhance user confidence and usefulness of systems in automated services.

Table 4 Misting Result

Trial	Mist Coverage Efficiency	Observed Output
1	91% Coverage	Uniform mist distribution; slight pooling at bottom
2	93% Coverage	Consistent atomization; fine droplet formation
3	95% Coverage	Highest efficiency, smooth brushing pattern
Mean	93% Coverage	Consistent atomization; fine droplet formation

The misting module shows a mean of 93% internal coverage, which shows consistent atomization with fine droplet formation which guaranteed even distribution of disinfectant and sanitized all surfaces of the helmets. More atomization at higher frequencies enhanced deodorizing operation and homogeneity in reaching the liquid, minimizing the chance of bacteria growth and odors.

Table 5 Design Features, System Components, and Operational Mechanism of the Automatic Helmet Sanitizer.

Aspect	Description	Function	Remarks
Design Features	Enclosed sanitizing chamber	Prevents External Contamination	Effective Containment
	Compact and ergonomic housing	Easy installation in public areas	Space-efficient
System Components	UV-C lamps (254 nm)	Microbial inactivation	High Sanitation Efficiency
	Motorized brush system	Removes dirt and debris	Stable and durable
	Raspberry Pi based Controller	Controls operation sequence	Reliable automation
	Misting	Dispenses Sanitizer	Hygienic and Touchless
	Multi-mode Payment System	Accepts multiple payment method (GCash, PayMaya, Crypto, Coin.)	User friendly and convenient
	Blower	Dries interior quickly.	Reduce odor and bacterial build up
	Sprinkler (Soap & Water)	Spray Water & Soap	Even Coverage
Operational Mechanisms	Automated cycle (30 seconds)	Consistent sanitization time	Optimal Exposure
	Contact + UV sanitation	Combined physical and chemical-free method	Improved Cleanliness

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Table 5 shows the design features, system components, and operational mechanisms of the automatic helmet sanitizer. The enclosed sanitizing chamber effectively prevents any external contamination with a remark of an effective containment. The compact and ergonomic housing allows easy installation in public areas and promotes space efficient.

In terms of system components, the (254 nm) UV- C lamps provides a microbial inactivation which contribute to high sanitation efficiency. The motorized brush system removes dirt, and debris, which ensures a stable and durable cleaning performance. The raspberry pi – based microcontroller manages the operation sequence of the automatic helmet sanitizer which it enables a reliable automation of the system. The misting module which function in sanitizer dispensing that provide a hygienic and touchless manner. The multi-mode payment system supports various kinds of payment methods that include GCash, PayMaya, cryptocurrency, and coins. The blower quickly dries the interior of the helmets, which contributes to the odor and bacteria reduction. There is also the sprinkler system that sprays soap and water making it an even coverage.

Regarding the operational mechanisms, the system will perform an automated 30-second cycle to keep a consistent time and at optimal exposure possible. Contact cleaning by means of brushing and UV sanitization increases the general cleanliness and makes the process of sanitizing more effective.

➢ *Microbiological Assessment*

Table 6 shows the sanitation parameter of the automatic helmet sanitizer prior to and after the sanitization procedure. Before the sanitization, the number of bacteria was determined to be about 1.5x 10^4 CFU/cm^2 and after the sanitization, the count of bacteria dropped to about 3.0x 10^3 CFU/cm^2, showing that a significant decrease in the bacterial load was achieved through the system.

Table 6 Sanitation Capability of the Automatic Helmet Sanitizer

Sanitation Parameter	Before Sanitization	After Sanitization	Remarks
Total Bacterial Count (CFU/cm^2)	~1.5 × 10^4 CFU/cm^2	~3.0 × 10^3 CFU/cm^2	Marked reduction in bacterial load achieved
Fungal Presence	Moderate to High	Low	Sanitization process effectively lowered contamination
Odor- Causing Bacteria	Present	Minimal	Sanitization substantially minimized bacterial presence
Overall Sanitation Efficiency Percentage	80% Sanitation Efficiency		

In terms of fungal presence, the contamination levels were recorded as moderate to high before sanitization of the system and reduced to low levels after sanitization of the system showing that the system was effective in reducing fungal contamination. There were bacteria that caused odor before the sanitization process but they were reduced after treatment, indicating that the sanitization cycle substantially reduced the presence of bacteria that cause unpleasant odor.

Overall, the system demonstrated an 80% of sanitation efficiency, which proves it to be a good measure in ensuring a significant reduction of microbial contamination within the interior of the helmet.

➢ *User Satisfaction Levels Metrics*

Table 7 shows the user satisfaction survey result. In terms of odor removal, the system scored 3.75 (very satisfied) which indicates that the users were highly satisfied in its ability to remove the odor of the helmet.

Table 7 User Satisfaction Survey

Category	Overall Mean	Verbal Interpretation
Odor Removal	3.75	Very Satisfied
Ease of Use	3.72	Very Satisfied
Multi-Mode Payment	3.76	Very Satisfied
Overall	3.74	Very Satisfied

For ease of use, the system scored 3.72 (very satisfied), indicating that the users found the automatic helmet sanitizer easy and convenient to operate. The multi- mode payment option recorded the highest mean score of

3.76 (very satisfied) reflecting strong user approval on the different payment options provided.

Overall, the automatic helmet sanitizer achieved a mean score of 3.74. This finding demonstrates a high level of user acceptance and satisfaction with the automatic helmet sanitizer.

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Table 8 Expert Satisfaction Survey

Category	Overall Mean	Verbal Interpretation
Odor Removal	4.00	Strongly Agree
Ease of Use	4.00	Strongly Agree
Multi-Mode Payment	4.00	Strongly Agree
Overall	4.00	Strongly Agree

Table 8 presents the expert's evaluation survey result. The system achieved a perfect mean score of 4.00 in all categories like odor removal, ease of use, and multi- mode payment, which are all verbally interpreted as Strongly Agree. This finding indicates that the system is highly effective in its odor removal ability, ease of use and provides flexible payment options.

➢ *Strengths and Weaknesses of the Prototype*

The tables below summarize the key strengths and Weakness of the Automatic Helmet Sanitizer across five aspects: system performance, usability, payment system, safety, and design. It highlights the effectiveness, user-friendliness, and reliability of the system in improving helmet hygiene and operational convenience.

Table 9 Strengths of the Automatic Helmet Sanitizer

Aspect	Key Strengths	Average Percentage
System Performance	High sanitation efficiency, consistent cycle time, effective odor reduction	86%
Usability	Simple operation, minimal user interaction, clear feedback	84%
Payment System	Supports QR and coin payments, automated verification	85%
Safety	UV auto shut-off, enclosed chamber, automatic stop during abnormal operation	84%
Design	Compact, portable, space- efficient, durable casing	84%

Table 9 provides the analysis of the system according to the strengths of the Automatic Helmet Sanitizer. Regarding the performance of the system, the device was highly sanitized with a consistent cycle time and odor reduction having an average of 86%, which is considered to have excellent operational reliability. The usability scored an average percentage of 84% which measures how easily it could be operated, the least amount of user interaction, and clear user feedback.

The payment system received an average percentage of 85%, indicating the users' appreciation for supporting QR and coin payments as well as its feature for automated verification. In terms of safety, an average percentage of 84%, which was due to the UV auto shut-off, enclosed chamber and an automatic stop capability during abnormal functioning. And finally, the design aspect scored an average percentage of 84%, with its space efficient, compact and durable casing. Overall, the results indicate a high level of performance, functionality, and user-centered design.

Table 10 Weakness of the Automatic Helmet Sanitizer

Aspect	Key Weaknesses	Average Percentage
System Performance	Limited capacity, fixed cycle duration, variable performance with soiled helmets.	51%
Usability	Needs instructional signage, lacks guidance prompts, may confuse non-tech users.	39%
Payment System	No card support, limited e- wallet compatibility, coin mechanism may jam.	46%
Safety	Requires maintenance, UV degradation, no real-time safety indicator.	27%
Design	Brush wear, limited space for larger helmets, aesthetic may need improvement	43%

Table 10 presents the weaknesses of the automatic helmet sanitizer. When it comes to system performance, it scored an average percentage of 51% with its limitation noted including limited capacity, fixed cycle duration and variable performance with soiled helmets. Helmet's usability has scored an average of 39%, which implies a notable area for improvement. The payment system got an average percentage of 46%, with concerns like non-card support, limited e-wallet compatibility and coin mechanism jamming. The lowest rating, which is recorded in terms of safety, scored an average percentage of 27%, which requires maintenance, UV degradation, and no real-time safety indicator. Finally, the design obtained an average percentage of 43%, with the problems identified as the brush wears, limited space for larger helmets, and aesthetic for improvement.

IV. CONCLUSION AND RECOMMENDATION

In conclusion, the Automatic Helmet Sanitizer with Multi-Mode Payment System and Brush met its design and performance goals. The use of a combination of UV-C light and misting coupled with brushing was effective in reducing microbial contamination as well as the bad odor. Users expressed a level of satisfaction with the ease of use, and convenient payment options in the system, and expert reviews proved that the system is reliable and functional. The system in general is a solution that is viable, effective and hygienic to helmet sanitation.

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It is recommended that the proposed modifications in the future must be made to ensure the digital payment network is more stable, mechanical components become more durable and more users should be tested. More safety measures, automatic service messages, and mobile surveillance might enhance the work of the system. Future studies can examine how to optimize energy, or implement more aggressive sanitization, or in more applications of the transport terminal and in educational institutions to bring the greatest benefit to the population.

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