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DEVELOPMENT OF MAINTENANCE MANAGEMENT SYSTEM FORENHANCE AVAILABILITY PERFORMANCE BY USING UAV

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ABSTRACT

This research aims to develop an effective maintenance management system for bridges by using unmanned aerial vehicles (UAVs) to enhance availability performance. Bridges are essential infrastructures that require regular maintenance to ensure their longevity and safety.However, traditional maintenance methods are often costly and time-consuming, leading to lower availability performance.

The proposed system incorporates UAVs for bridge inspection, data collection, and analysis,allowing for timely and accurate identification of potential maintenance issues. The collected data is then analyzed using artificial intelligence and machine learning algorithms to predict and prioritize maintenance needs, enabling the efficient allocation of resources.

The system's effectiveness will be evaluated based on several factors, including maintenance costs, downtime reduction, and availability performance improvement. The research will alsoconsider the potential impact of weather conditions on the UAV's ability to operate effectively and the ethical considerations surrounding UAV usage for bridge maintenance.

The research aims to provide insights into the potential benefits of using UAVs for bridgemaintenance and their impact on availability performance, which could inform future maintenance strategies for critical infrastructure.

Keywords: **Maintenance Management System, Availability Performance, UAV**

1. INTRODUCTION

Bridges are critical infrastructure that plays a crucial role in transportation, commerce, and public safety. However, over time, bridges can deteriorate due to various factors such as weather, aging, and traffic loads. Therefore, regular maintenance of bridges is essential to ensure their safety, availability, and longevity.

Traditionally, bridge inspections are performed manually by human inspectors, which can be costly, time-consuming, and hazardous. Moreover, manual inspections may not provide a comprehensive assessment of the bridge's condition, leading to inadequate maintenance, which can result in costly repairs or even bridge failures.

Currently Tanzania relies on manual inspections, which can be time-consuming, expensive, and hazardous. Moreover, the manual inspections may not provide a comprehensive assessment of the bridge's condition, leading to inadequate maintenance and repair.

The use of UAV technology in bridge inspection and maintenance management in Tanzania can significantly improve the safety, availability, and longevity of bridges while reducing costs and enhancing public safety. UAVs can provide a comprehensive and accurate assessment of the bridge's condition, detect defects, and perform routine maintenance tasks.

Moreover, the use of UAV technology in bridge inspection and maintenance management in Tanzania can create employment opportunities for local people in the UAV industry, including pilots, technicians, and support staff.

Overall, the development of an effective maintenance management system for bridges that utilizes UAV technology to enhance availability performance in Tanzania can improve the safety and availability of bridges, reduce costs, enhance public safety, and create employment opportunities.

2. METHODOLOGY

Within the context of implementing an efficient maintenance management system for bridges, leveraging UAV technology involves several pivotal processes. Foremost, data analysis assumes a central role, harnessing the capabilities of machine learning and artificial intelligence to unveil intricate data patterns and detect anomalies. This analytical insight serves as the compass for crafting maintenance and repair plans, a process that entails prioritizing actions based on issue severity while diligently recording every inspection detail. To optimize efficiency, sampling techniques are deployed, strategically curbing costs and time commitments while meticulously identifying structural defects and concerns spanning the entire bridge. The sampling workflow comprises pinpointing inspection areas, selecting tailored sampling methodologies, and executing inspections through UAVs equipped with advanced cameras and sensors. To ensure comprehensive representation, a thoughtfully designed sampling strategy ensures the precise reflection of the bridge's overall condition. A suite of research instruments and tools, ranging from UAVs and sensors to machine learning, geographic information systems (GIS), and data visualization utilities, are seamlessly integrated to gather, scrutinize, and visually interpret bridge-related data. These multifaceted tools aid in pinpointing areas susceptible to environmental factors and play a pivotal role in informed decision-making regarding maintenance and repair strategies. The arsenal of data collection techniques encompasses visual inspections, infrared thermography, LiDAR scanning, ultrasonic testing, and corrosion mapping. Conclusively, the arsenal of data analysis techniques comes into play, transforming collected data into actionable insights to steer effective maintenance and repair planning processes.

3RESULTS

3.1 Introduction

This chapter of a dissertation plays a crucial role in conveying the outcomes of the data analysis conducted to address the research questions. Its primary objective is to present a thorough and in-depth description of the findings, employing various statistical analyses, tables, and visual aids to ensure a structured and lucid representation of the results. Additionally, the chapter offers an interpretation of the findings, emphasizing their significance and implications for both the research questions and the wider field of study. The presentation of the results aims to foster a comprehensive understanding of the research topic while substantiating the overarching argument of the dissertation.

3.2 Respondents Characteristics

The study focused on developing a maintenance management system for bridges utilizing Unmanned Aerial Vehicles (UAVs) and featured respondents with distinct characteristics. These respondents were categorized based on their roles within the field, revealing that 45.5% were bridge maintenance inspectors, 29.5% were engineering professionals, and 25% were technicians. Additionally, the study considered the respondents' years of experience, with the largest group having 15-20 years of experience (29.5%), followed by those with 5-10 years (22.7%), 10-15 years (20.5%), 0-5 years, and 20 years and above (each comprising 13.6%).

This diverse distribution of respondents' characteristics offers valuable insights. Including individuals from various roles ensures a comprehensive understanding of the requirements and challenges associated with implementing a maintenance management system employing UAVs in bridge maintenance. Moreover, the inclusion of respondents with varying levels of experience enriches the study's perspective. More experienced individuals bring historical context and deep knowledge of traditional maintenance practices, while those with less experience contribute fresh insights and familiarity with emerging technologies. By considering both position and experience, the study aims to capture a wide range of expertise and viewpoints, ultimately enhancing the relevance and applicability of its findings. This comprehensive approach is instrumental in developing a system that can effectively address the diverse needs and challenges faced by stakeholders in the field of bridge maintenance.

Table 3.1: **Respondents characteristics**

VARIABLE	RESPONSE	FREQUENCY	PERCENT (%)
Position	Engineering	13	29.5
	Technician	11	25.0
	Inspectors	20	45.5
Year of experience	0-5 Years	6	13.6
	5-10 years	10	22.7
	10-15 years	9	20.5
	15-20 years	13	29.5
	20 years and above	6	13.6
TOTAL		**44**	**100**

Source: Researcher

3.3 Defects to consider during BMMS

The relative importance index (RII) is a measure used to assess the importance of various defects that need to be considered during Building Maintenance Management System (BMMS) maintenance. The RII values associated with each defect can provide insights into their relative significance and help prioritize maintenance efforts accordingly.

Cracks, with an RII value of 0.72, are considered relatively important in the context of BMMS maintenance. Cracks in the building structure can compromise its integrity and pose safety risks. Therefore, it is crucial to identify and address cracks promptly to prevent further damage and ensure the structural stability of the building.

Deformations, with an RII value of 0.59, are also considered significant. Deformations refer to changes in the shape or form of structural elements. They can be caused by various factors, such as excessive loads, temperature changes, or material deterioration. Monitoring and addressing deformations are essential to maintain the structural integrity and functionality of the building.

Displacement, with an RII value of 0.57, is another defect that requires attention during BMS maintenance. Displacement refers to the shifting or movement of building components from their original positions. It can lead to imbalances, misalignments, and potential structural failures. Detecting and rectifying displacements in a timely manner is vital for maintaining the stability and safety of the building.

Deteriorations, with an RII value of 0.58, indicate the importance of considering the gradual degradation or decay of building materials and components. Deteriorations can be caused by environmental factors, aging, or lack of proper maintenance. Monitoring and addressing deteriorations are essential to prevent further damage, maintain functionality, and extend the lifespan of the building.

Spalling, with an RII value of 0.67, is a defect that requires attention during BMMS maintenance. Spalling refers to the breaking off or chipping of concrete or other building materials from the surface. It can occur due to factors like freeze-thaw cycles, chemical exposure, or poor construction practices. Addressing spalling is crucial to maintain the aesthetics, integrity, and durability of the building.

Corrosion, with an RII value of 0.66, is an important defect to consider during BMMS maintenance. Corrosion refers to the gradual deterioration of metals caused by chemical or electrochemical reactions with the environment. It can weaken structural elements, compromise safety, and lead to functional failures. Regular inspection and corrosion prevention measures are necessary to mitigate its impact.

Wear and tear, with an RII value of 0.59, indicate the significance of considering the normal deterioration or damage that occurs over time due to regular usage. Wear and tear can affect various building components, such as flooring, fixtures, or mechanical systems. Monitoring and addressing wear and tear are essential to maintain the functionality, aesthetics, and safety of the building.

Other defects that should be considered during BMMS maintenance include loose bolts (RII: 0.66), joint and expansion gaps (RII: 0.63), delamination (RII: 0.63), fatigue (RII: 0.67), settlement (RII: 0.63), holes (RII: 0.62), and buckling (RII: 0.58). Each of these defects has its own specific implications for the structural integrity, functionality, and safety of the building, and they should be addressed accordingly during BMMS maintenance activities.

In brief, the RII analysis provides valuable insights into the relative importance of various defects during BMMS maintenance. Considering and addressing these defects proactively can help ensure the long-term durability, safety, and functionality of the building.

Table 3.2: Defects to consider during BMMS

	SA	A	UNC	D	SD	∑W	A	N	A*N	RII
	5	4	3	2	1					
Cracks	145	36	6	8	0	195	54	5	270	0.72
Deformations	10	88	60	0	0	158	54	5	270	0.59
Displacement	20	64	66	4	0	154	54	5	270	0.57
Deteriorations	35	52	66	4	0	157	54	5	270	0.58
Spalling	75	80	27	0	0	182	54	5	270	0.67
Corrosion	75	64	39	0	0	178	54	5	270	0.66
Wear and tear	10	88	60	0	0	158	54	5	270	0.59
Lose bolt	85	56	33	4	0	178	54	5	270	0.66
Joint and expansion gaps	35	108	24	4	0	171	54	5	270	0.63
Delamination	60	60	51	0	0	171	54	5	270	0.63
Fatique	75	80	27	0	0	182	54	5	270	0.67
Settlement	85	52	18	16	0	171	54	5	270	0.63
Holes	40	80	48	0	0	168	54	5	270	0.62
Bucking	10	88	54	4	0	156	54	5	270	0.58

4 DISCUSSION OF RESULTS

4.1 Identifying defects which might be captured by UAV

In the context of a Building Maintenance Management System (BMMS) integrated with Unmanned Aerial Vehicles (UAVs), the Relative Importance Index (RII) serves as a valuable tool for evaluating the significance of different defects that can be identified and assessed by UAVs. Among these defects, cracks emerge as particularly critical, boasting an RII value of 0.72. Cracks possess the potential to jeopardize a building's structural integrity and pose safety risks. Timely detection and intervention are of paramount importance to prevent further deterioration and uphold the overall stability of the structure. This observation aligns with the findings of Zhang and Guan (2018), who emphasized the importance of addressing cracks in the context of bridge inspection using UAVs.

Another defect that demands attention is deformations, with an RII value of 0.59. Deformations can significantly impact a building's structural elements, whether caused by excessive loads or material deterioration. Hence, ongoing monitoring and the proactive mitigation of deformations are essential to ensure the continued structural integrity and functionality of the building. These findings are consistent with the research conducted by Huang et al. (2019), which highlighted the importance of addressing deformations during bridge inspections using UAVs. However, it's worth noting that this perspective contradicts the findings of Chen et al. (2019).

Displacement, with an RII of 0.57, represents another substantial defect that merits attention within the context of BMMS implementation. The movement or shifting of building components from their original positions can lead to imbalances, misalignments, and even structural failures. Detecting and rectifying displacements in a timely manner are vital to maintaining the building's stability and safety. It's worth noting that this finding contradicts the work of

Zhang and Guan (2018), who found that displacement was most significant in the context of bridge inspection using UAVs.

Deteriorations, with an RII value of 0.58, underscore the importance of considering the gradual degradation or decay of building materials and components. These deteriorations can result from environmental factors or inadequate maintenance practices, making ongoing monitoring and proactive intervention crucial to prevent further damage, maintain functionality, and extend the building's overall lifespan. However, these findings contrast with the results of Zhu and Cui (2019), who emphasized the significance of addressing deteriorations in bridge inspections using Autonomous Underwater Vehicles (AUVs).

Spalling, assigned an RII value of 0.67, represents yet another defect that demands attention. Spalling involves the breaking off or chipping of concrete or other building materials from the surface, impacting both aesthetics and structural integrity. Addressing spalling is crucial to preserve the building's appearance and ensure its overall durability. In this regard, the findings align with the research conducted by Huang et al. (2019), emphasizing the importance of addressing spalling during bridge inspections.

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