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## MONITORING OF THE STRUCTURAL CONDITION OF CONSTRUCTION OBJECTS

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Modern research methods involve the utilization of unmanned aerial vehicles (UAVs) for the inspection of buildings and the collection of high-precision data. These data are integrated into Building Information Modeling (BIM) systems for visualization and analysis, while machine learning algorithms are applied for the prediction and assessment of structural damage.

The advancement of such technologies is particularly significant for Ukraine, which is actively reconstructing its infrastructure following extensive destruction. The integration of digital technologies, such as Geographic Information Systems (GIS) and monitoring systems, accelerates the assessment of damage and the planning of reconstruction efforts. The use of drones and satellite data facilitates the management of large-scale projects and reduces risks in hazardous zones. Furthermore, the implementation of innovative technologies, including BIM, enhances the efficiency of design and construction processes. Ukraine holds substantial potential for leveraging these technologies to ensure infrastructure resilience and improve safety under external challenges.

Sensor networks provide continuous real-time monitoring of the structural condition of construction objects. Combining UAVs, BIM, and machine learning enables the rapid detection of damage as well as efficient analysis and prediction of its progression, significantly reducing time and costs compared to traditional methods.

Drones equipped with high-quality cameras and sensors are highly effective for identifying structural defects such as cracks, corrosion of metal elements, structural displacements, and roof deformations. Their capability to survey hard-to-reach or hazardous areas allows for the detection of even microscopic damage, which is often overlooked by traditional methods.

The use of UAVs dramatically reduces the time required for technical inspections of buildings while enhancing the precision and frequency of monitoring. Compared to traditional methods, such as manual inspections or the use of lifts, drones offer a more detailed and objective examination while minimizing risks to personnel. Research indicates that UAVs can identify damage at its early stages, enabling timely interventions to prevent critical failures and reduce repair costs.

Key challenges in the reconstruction and construction of military installations under wartime conditions have been studied by Frolov and his co-authors (2024). Their research focuses on developing new approaches to design and construction that enhance the resilience and efficiency of facilities in conflict environments.

The prospects for employing remote technologies in monitoring construction structures are highly promising, as these technologies facilitate inspections in hard-to-reach or hazardous areas, significantly reducing risks for personnel.

Combining UAVs, photogrammetry, and LiDAR technologies enables the acquisition of highly accurate data on the condition of construction objects, improving the efficiency of technical inspections and reducing the influence of human error in data collection.

Remote technologies also open new avenues for automating defect detection processes through machine learning algorithms capable of processing large volumes of data. This accelerates and enhances diagnostic accuracy, improving the safety and durability of construction structures.

Additionally, integrating these technologies into BIM systems allows for the creation of detailed real-time models, enabling more precise planning and management of maintenance processes. Tregub (2023) examines the legal aspects of managing construction and demolition waste resulting from armed conflicts.

UAVs provide unique opportunities for data collection in hard-to-reach or hazardous zones where traditional monitoring methods are impractical or prohibitively expensive. Equipped with high-resolution cameras and sensors, UAVs can capture even the smallest defects, such as cracks, metal corrosion, or structural displacements. A variety of sensors are used for monitoring the integrity of buildings, including those for measuring deformation, temperature, humidity, as well as accelerometers and gyroscopes for detecting vibrations. These sensors can be installed directly on structures or integrated into monitoring systems through UAVs.

UAVs equipped with cameras, thermal imagers, and LiDAR scanners provide highly accurate data on the condition of buildings. This information is integrated into BIM systems, where specialized software facilitates data analysis, the creation of 3D models, and real-time assessment of structural stability. This approach ensures an accurate representation of the current state of buildings, enabling the timely detection of defects or potential threats of structural failure.

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