

HydroSense: Smart Water tank condition Assessment Using AI and Computer Vision

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Abstract:

Water tanks in homes and buildings are often checked too late, which allows algae, sediment, and other contamination to build up unnoticed. This paper presents a simple monitoring system that uses a Raspberry Pi, a camera, and controlled LED lighting to inspect the inside of the tank without placing any sensor in the water. The images are processed locally using OpenCV to estimate algae spread, turbidity, and overall tank condition, which are combined into a Water Health Score. The result is sent to AWS IoT Core through MQTT, stored in a device shadow, and used to trigger mobile alerts when the tank needs cleaning.

Keywords: Edge Computing, Computer Vision, AWS IoT Core, Predictive Maintenance, Water Quality Analytics, Cyber-Physical Systems, Raspberry Pi, MQTT, Water Health Score, Firebase Cloud Messaging.

INTRODUCTION

Safe water storage is important in both homes and industrial buildings, but overhead tanks are usually inspected only occasionally. Because of that, problems like algae growth, sediment buildup, and cloudy water may continue for days or weeks before anyone notices. Traditional monitoring methods usually focus on water level or chemical readings, but they often need frequent maintenance and can fail when submerged sensors become dirty or unstable. To solve this, the proposed system uses vision instead of direct water contact. A camera and Raspberry Pi inspect the tank interior, and the software turns those visual signs into a practical health indicator that helps users act earlier. As an inspection system, the proposed solution reduces maintenance requirements while providing a reliable method for monitoring tank cleanliness and predicting cleaning schedules.

LITERATURE REVIEW

Earlier research on water monitoring has shown that chemical sensors can provide accurate readings, but they are not always reliable in long-term real-world use because of bio-fouling and calibration drift. Computer vision has become a stronger option because it can detect visible changes such as algae patches and turbidity

without needing submerged probes. Recent IoT systems also show that edge-cloud setups are useful because they let the device process images locally while still keeping the latest results in the cloud for remote access and alerts.

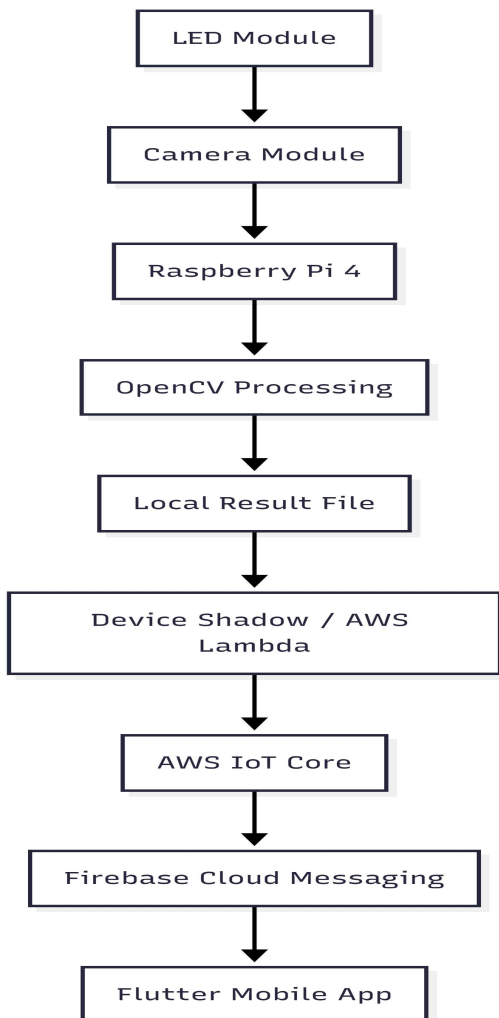
EXISTING SYSTEM

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PROPOSED SYSTEM

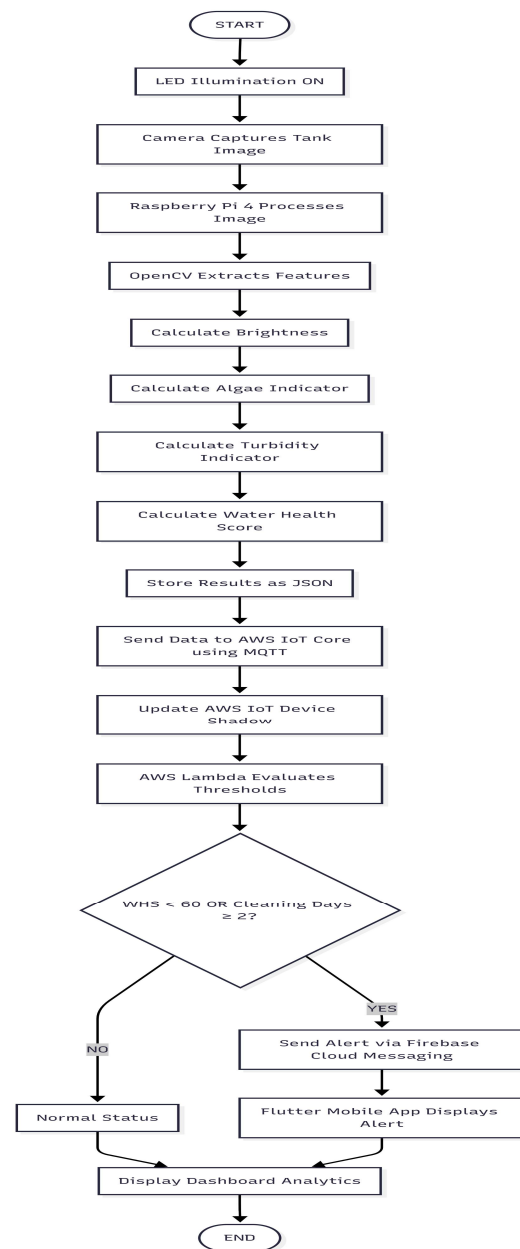
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BLOCK DIAGRAM



System Architecture

The system uses an edge-to-cloud structure. The edge layer handles image capture and local analysis, while the cloud layer stores the latest data and supports alert delivery. This architecture keeps the system lightweight because the heavy work is done locally, while the cloud only handles synchronization and user notification. It also makes the monitoring process more reliable because the latest state remains available even if the edge device temporarily disconnects.



Methodology

The process runs automatically in a cycle. First, the LED turns on and the camera captures multiple images. Then the software analyzes the images, calculates the health score, uploads the result, and checks whether an alert should be sent.

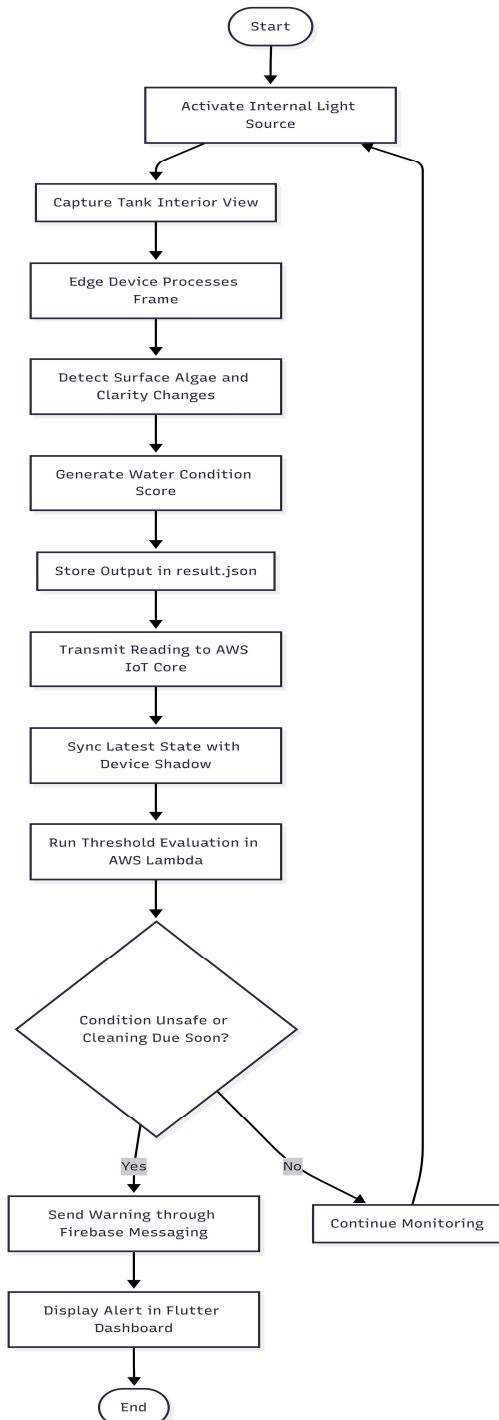


IMAGE PROCESSING

The image pipeline first converts the captured frame from RGB to HSV, which makes it easier to isolate green algae regions. It then uses color masking to estimate algae area and Laplacian variance to estimate image sharpness and water clarity. These values are merged into a single Water Health Score, which is used to classify the tank as Excellent, Good, Average, Poor, or Critical.

Comparison With Existing Systems

Metric	Older systems	Proposed system	Why it is better
Main focus	Water level only	Water level plus visible tank health	Gives a fuller picture of tank condition
Maintenance	Low for float sensors, high for probes	Lower maintenance because it is non-contact	Less cleaning and calibration needed
Algae detection	Not available or indirect	Direct visual detection	Detects contamination earlier
Cloud support	Limited or absent	AWS IoT Core and device shadow	Better remote access
Maintenance style	Reactive or fixed schedule	Predictive cleaning alerts	More efficient planning

EXPERIMENTAL RESULTS

The prototype was tested for 30 days using a tank with increasing amounts of organic waste, soil, and micro-algae. As contamination increased, the algae area ratio increased and the Water Health Score dropped in a steady pattern, moving from

Excellent to Critical. This shows that the method can detect water quality changes early enough to support planned cleaning rather than emergency response

DISCUSSION

The results suggest that the system works better than manual checking because it identifies visible deterioration before it becomes obvious to the eye. The cloud shadow feature also helps because the mobile app can still show the latest reading even if the edge device goes offline briefly. Overall, this makes the system practical for real buildings where maintenance needs to be simple and timely.

ADVANTAGES

- Non-contact sensing avoids fouling and calibration drift.
- Early detection of algae and turbidity improves safety.
- Predictive cleaning reduces emergency maintenance.
- Cloud logs and alerts improve reliability and access.

LIMITATIONS

The system depends on stable lighting, so LED failure can affect image quality and scoring accuracy. Condensation or dirt on the camera window can also distort the results. It is useful for visual condition monitoring, but it does not directly measure chemical water parameters.

FUTURE WORK

Future versions could use stronger prediction methods such as LSTM models to improve long-term forecasting. A motorized camera setup could help inspect larger tanks from multiple angles. Lighting correction and lens-cleaning support could also improve robustness.

CONCLUSION

This paper presents a practical water tank monitoring system that uses computer vision, edge

processing, and cloud alerts to detect contamination without direct water contact. Compared with level-only or probe-based systems, it is easier to maintain and more useful for preventive cleaning. It is a strong fit for modern buildings where reliability, low maintenance, and early warning matter.

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