

AI-Powered Intelligent Water Tap System for Enhanced Water Conservation

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Abstract: Water scarcity is a growing global crisis, aggravated by population growth, climate change, and inefficient water management. This issue necessitates new and efficient conservation techniques. This study provides insight into sophisticated AI-powered intelligent water tap systems that combine computer vision algorithms: YOLO (You Only Look Once) models, with OpenCV image processing and embedded computing on a Raspberry Pi platform.

This system prevents wastage by intelligently controlling usage and optimizing water flow. It happens by using AI real-time monitoring, automation, and categorizing routine household tasks like brushing teeth, washing face, and hands. It modifies water flow hence enhancing sustainability, ensuring water conservation in households. Extensive experimental evaluations highlight significant water-saving potentials, system reliability, and practicality for widespread residential adoption.

INTRODUCTION

Innovative conservation technology is the need of the hour. Domestic water management needs intelligent automation, as conventional household water-saving methods rely on passive mechanisms or manual control.

This study introduces an advanced AI-powered tap system that autonomously regulates water usage in real time, dynamically adjusting flow based on user interactions. By precisely aligning water dispensation with actual needs, it optimizes usage and minimizes wastage, offering a more responsive and effective solution for sustainable water management.

LITERATURE REVIEW

Traditional water-saving solutions help regulate water flow using timed shutoff valves, low-flow faucets, and infrared sensors. However, these problems were encountered:

- Lack of precision in water usage control.
- Fail to intelligently adapt to specific user activities.
- Caused inconvenience to users.

The YOLO model and OpenCV-based real-time image processing offer new possibilities for intelligent water conservation. There is a great chance for innovation because their use in intelligent home water saving is still mainly untapped.

System Design and Architecture

The following hardware and software components are interconnected:

Hardware Components

- Camera Module: Raspberry Pi camera to capture high-resolution real-time images of user activities.
- Infrared Sensors: To detect user proximity and motion.
- Pressure Sensors: To accurately measure real-time water flow and provide feedback to optimize water usage.
- Raspberry Pi Platform: Serves as the embedded computing platform for real-time processing, activity recognition, and valve control.

Software Components

- OpenCV Library: Handles real-time image pre-processing tasks like grayscale conversion, noise removal, contrast enhancement, and object detection preparation.
- YOLO Object Detection Models: Utilizes YOLOv5, optimized for speed and performance on embedded systems, for real-time activity classification.
- GPIO Valve Control Module: Executes precise control of the water valve based on YOLO model outputs, adjusting flow rates dynamically to conserve water.

METHODOLOGY

The framework involves:

- Data acquisition
- Preprocessing
- Model training
- System validation

Experimental Setup

A prototype of an intelligent tap was developed and tested in a lab under realistic residential conditions. Various user activities were evaluated to assess

detection accuracy, responsiveness, and water-saving efficiency.

RESULTS

The intelligent water tap demonstrated robust performance, achieving the following:

Activity	Detection Accuracy:
Teeth Brushing	96%
Face Washing	93%
Handwashing	95%
Water Conservation Performance: Achieved water savings between 35% to 50% compared to conventional taps.	
Computational Efficiency: Real-time YOLOv5 model inference on Raspberry Pi with negligible latency.	
<ul style="list-style-type: none"> Detailed metrics, including precision, recall, F1-score, and confusion matrices, affirmed the system's reliability. 	

CONCLUSION

This research introduces an intelligent and automated water management tap system using YOLO models,

OpenCV, and Raspberry Pi for real-time. Tests showed considerable water savings and system reliability, offering a feasible and scalable solution for household water conservation and sustainability.

Diagram:



