Design Practicum

Topic - AUTOMATED MODE CHANGE ADD ON FOR TAP

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Introduction

Abstract:

With the help of voice recognition technology, our product will create a novel add-on for kitchen water taps that will enable automatic mode switching in response to user orders. With the help of this technology, users can easily modify the water flow settings in their kitchen routines, which improves convenience and efficiency. The technology aims to optimize water usage by providing tailored control options, thereby promoting sustainable practices within household

Problem Statement:

The objective is to develop a water tap system that autonomously adjusts water flow based on usage patterns, thereby promoting water conservation without compromising user experience. The system should be versatile enough to adapt to various kitchen setups and user preferences.

Unlocking the Necessity: Solving the Critical Issue:

- With global water scarcity on the rise, there's a pressing need for technologies like this to promote responsible water usage.
- The add-on's ability to switch water modes via voice commands offers unmatched convenience, encouraging users to be more mindful of their water consumption.
- Tailoring water flow to individual needs ensures optimal usage, minimizing waste and saving money on water bills.
- Integrating voice recognition with kitchen taps not only enhances functionality but also aligns with the growing trend of smart home technology adoption, making it a valuable addition to modern households

Existing/Related Works

Several initiatives and technologies exist in the realm of water conservation and smart home automation. Some notable examples include:

1. This is the mode changing add on for kitchen tap. It has 3 modes and is made of stainless steel and ABS composite resin. Mode is changed manually itself by the user by pressing the buttons provided. The modes have shower mode in it which helps in water conservation and it is also 360 degrees rotatable and the cost is low too.

2. Similarly, as previous one this one also has 3 modes and this is made of Stainless steel, ABS and silicone. It also has shower mode to help conserve water and concentrated mode to help in ease washing utensils and it also has a 360-degree rotatable head to wash sinks easily. Just like the previous one it is also operated manually by buttons. This also has low cost.

3. This add-on has a unique design than previous ones. Its size is quite large compared to previous ones but the purpose and results are quite similar due to its size. It has the advantage of washing large surfaces in less time and also has pressurization mode to help wash cups easily. Overall, this also helps in water conservation. It is more costly than previous ones.

Methodology

Research and Requirement Analysis

We started by conducting extensive research on existing water tap systems, automation technologies, and water conservation methods. This foundational work helped us understand the landscape and identify key features and capabilities for our add-on.

Conceptualization and Design

We brainstormed and ideated various concepts for the automated water tap system, considering factors such as sensor types, control mechanisms, user interface design, and compatibility with existing plumbing fixtures. Preliminary design sketches and flow diagrams were created to visualize the system architecture and workflow. We evaluated these design concepts based on feasibility, cost-effectiveness, scalability, and their potential impact on water conservation goals.

Component Selection and Prototyping

Next, we identified suitable sensors, actuators, microcontrollers, and other hardware components needed for system implementation. We procured or prototyped essential components for experimental testing and validation. Prototype circuits and firmware were developed to integrate sensors with control mechanisms, ensuring compatibility and functionality.

System Development

We developed software algorithms to analyze sensor data, detect usage patterns, and make intelligent decisions regarding water flow regulation. Control logic for automated mode switching based on predefined thresholds and user-defined preferences was implemented. We also integrated user interface elements such as buttons to enhance user interaction.

Testing and Validation

To confirm functionality, accuracy, and dependability, comprehensive testing was carried out on both individual parts and integrated system modules. We ran simulated usage scenarios to evaluate the system's response to different situations and stress levels. Data on water usage, flow rates, and user interactions were collected to assess the effectiveness of our water-saving strategies and overall user satisfaction.

Refinement and Optimization

During the project, we continuously identified areas for optimization and improvement. By iterating on our design and implementation based on test feedback, we enhanced system responsiveness and performance. This involved adjusting control thresholds, fine-tuning sensor calibration settings, and modifying algorithm parameters. We also addressed any software or hardware issues that arose during troubleshooting, debugging, and testing to ensure the system operated smoothly and efficiently.

Through this methodology, our project aimed to develop a reliable and user-friendly automated water tap system that effectively promotes water conservation in kitchen settings.

Mechanical Implementation

Reverse Engineering Analysis

- **Faucet Examination:** After dissecting the faucet, we discovered that the Jet, Normal, and Spray modes are selected by a rotating part that resembles a knob or lever. This component's rotation causes internal adjustments that redirect water flow appropriately.
- **Internal Mechanism:** Further investigation indicated that the faucet assembly contains a diverter valve. This valve controls the flow of water to various outlets or nozzles in accordance with the selected mode.
- **Mode Selection:** Users can manually switch between modes thanks to the knob or lever that interfaces with the diverter valve. Depending on the faucet design, this interface mechanism's specifics can change, but it usually uses cams or mechanical linkages to activate the diverter valve.

Proposed Solution

A servo motor-based system is used to automate the mode changeover procedure and offer dynamic flow control. Here's how we made it happen:

- **Servo Motor Integration:** We installed a servo motor assembly inside the faucet housing, oriented so that it can communicate with the current mode selection device. Remote control and automation are made possible by the servo motor's ability to imitate the manual motion of a knob or lever through rotation.
- **Linkage Design:** We created a linkage system that converts the servo motor's rotating motion into the linear or rotary movement needed to open the diverter valve. To ensure

smooth integration with the current faucet assembly, this linkage behaves similarly to the manual mode selector.

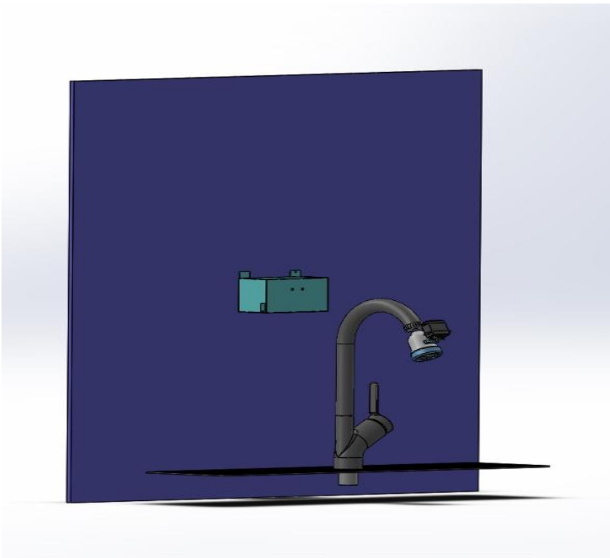
- **Control System:** To regulate the servo motor's operation, we implemented a control system, using a voice sensor with a microphone and speaker attached to it. This control system allows users to remotely change the faucet mode by sending voice commands through the sensor and we have implemented voice to text models to handle the functionality.

- **Testing and Calibration:** We carried out thorough testing and calibration to confirm the automatic mode switching system's reliability and performance. We adjusted the linkage geometry, control algorithms, and servo motor parameters as needed to maximize functionality and user experience.

By implementing this servo motor-based technology, the faucet now offers automatic mode switching and dynamic flow control capabilities. This not only promotes water saving and enhances user convenience but also aligns with the trend towards smart and sustainable home technologies.

Mechanical design:

1. Servo Motor Holder
2. Voice Sensor
3. Blackbox (Containing the electrical components)

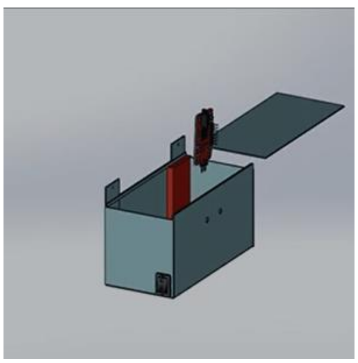


Different Modes:

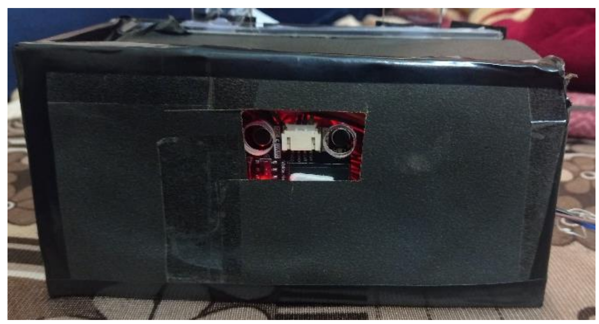
Shower Mode

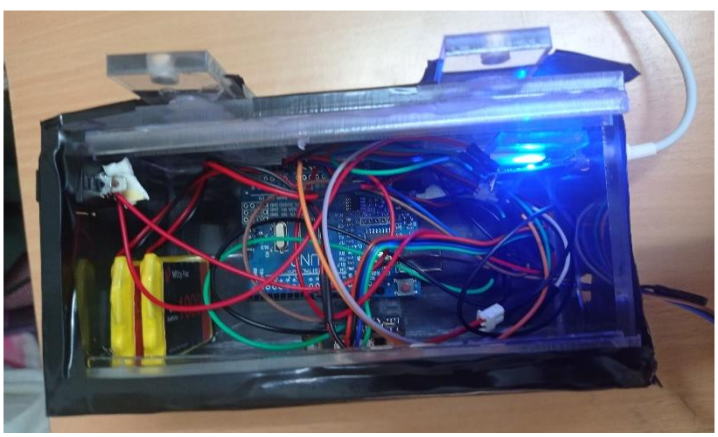
Jet Mode

Blackbox:



1. Voice Recognition Module
2. Arduino Uno
3. Charging Module
4. Rechargeable Batteries
5. Switch





Connections

Coding Implementation

Initial Approaches:

1. **Voice to Text Models Using Machine Learning:** Initially, we explored voice-to-text models using machine learning. However, this approach was ineffective due to the time it took to sense the voice and generate the associated text. Consequently, we discarded this idea and searched for alternative solutions.
2. **Web Server for Voice Recognition:** We then created a web server for voice recognition, which proved to be faster than our previous method. However, this approach was cloud-based and required an internet connection, making it unsuitable for our needs. Thus, we abandoned this approach and sought offline solutions.

Final Approach:

- We ultimately opted for an offline solution using IoT sensors for voice recognition. Specifically, we utilized the DF Robot offline voice recognition module for our model.
- This module comes with built-in commands and allows for training custom commands. We trained the sensor with our custom commands for mode switching.
- The sensor's internal process involves matching the frequency maps generated by different sounds it recognizes and then mapping them to the learned frequency maps.
- The custom commands we trained were:
    - Shower Mode
    - Normal Mode
    - Jet Mode

- These commands were aligned with our mode-switching add-on. Once the sensor recognized these commands, we configured a servo motor to execute the corresponding functionality.
- We determined the angles for the different modes and programmed the servo motor to adjust to these angles based on the recognized commands. This approach enabled us to create an offline, voice-activated mode-switching add-on for kitchen water taps.

Coding Snippets:

```
void setup() {
    Serial.begin(115200);
    servo.attach(9);

    // Init the sensor
    while (!(asr.begin())) {
      Serial.println("Communication with device failed, please check connection");
      delay(3000);
    }
    Serial.println("Begin ok!");
    asr.setVolume(100);
    asr.setMuteMode(0);
    asr.setWakeTime(100);
    uint8_t wakeTime = 0;
    wakeTime = asr.getWakeTime();
    Serial.print("wakeTime = ");
    Serial.println(wakeTime);

    asr.playByCMDID(1);   // Wake-up command
    asr.playByCMDID(23);  // Command word ID
}
```

Waking up the Sensor

```
  switch (CMDID) {
    case 5:
      Serial.println("Shower");
      servo.write(120);
      previous=CMDID;
      break;

    case 7:
      Serial.println("Spray");
      servo.write(180);
      previous=CMDID;
      break;

```

Shower and Jet Mode

```
    case 6:
      Serial.println("Default");

      //Coming from shower
      if(previous==5){
        servo.write(145);
      };

      //Coming from jet
      else if(previous==7){
        servo.write(155);
      }

      //Coming from normal
      else if(previous==6){
        continue;
      }

      //Neutral (not in any mode)
      else{
        servo.write(150);
      }

      previous=CMDID;
      break;
```

Normal Mode

Methodology for Electrical Circuit:

Component Selection and Preparation:

1. Arduino Uno: Chosen as the microcontroller to manage inputs and outputs.
2. DFRobot Voice Recognition Module: Selected for its offline voice recognition capability.
3. Servo Motor: Used to physically adjust the water tap based on voice commands.
4. 18650 Lithium-Ion Battery: Provides a portable power source.
5. TP4056 Charging Module: Ensures the battery can be recharged safely.
6. On/Off Switch: Allows for manual control of the circuit power

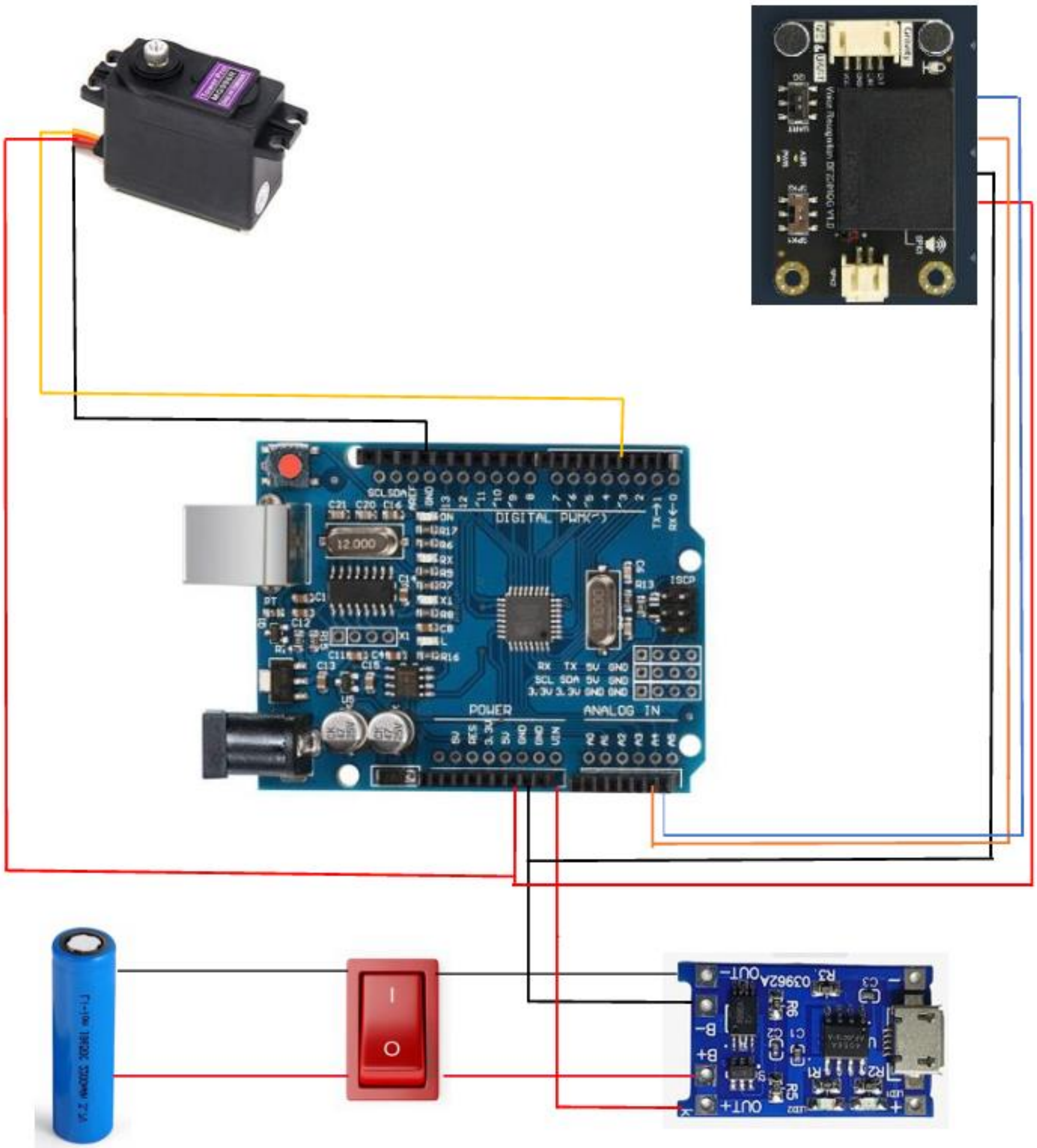
Circuit Design:

- **Power Supply Configuration:**
  - Connect the positive terminal of the 18650 Lithium-Ion Battery to the IN+ terminal of the TP4056 Charging Module.
  - Connect the negative terminal of the battery to the IN- terminal of the TP4056.
  - Wire the OUT+ terminal of the TP4056 to one side of the On/Off Switch.
  - Connect the other side of the switch to the Vin pin on the Arduino Uno.
  - Wire the OUT- terminal of the TP4056 to the GND pin on the Arduino.

- **Voice Recognition Module Setup:**
  - Connect the SDA pin of the Voice Recognition Module to the A4 (SDA) pin on the Arduino.
  - Connect the SCL pin of the Voice Recognition Module to the A5 (SCL) pin on the Arduino.
  - Wire the VCC pin of the module to the 5V pin on the Arduino.
  - Connect the GND pin of the module to the GND pin on the Arduino.

- **Servo Motor Connection:**
  - Attach the signal wire of the Servo Motor to the digital pin 9 on the Arduino.
  - Connect the VCC wire of the Servo Motor to the 5V pin on the Arduino.
  - Connect the GND wire of the Servo Motor to the GND pin on the Arduino.

Circuit Diagram:



Circuit Diagram

Testing results

Type of Mode	Volume(ml)	Time (sec)	Flow Rate (ml/sec)
Jet	700	6.13	114.19
Normal	700	5.23	133.84
Shower	700	6.23	112.35
Without Add on	700	4.81	145.53

Type of Mode	Percentage of water saved
Jet Mode	21.49%
Normal Mode	8%
Shower Mode	22.75%
Average	17.41%

- **Without Add-On:** This serves as the baseline for comparison with the other modes.
- The average percentage water saving across all modes is calculated as 17.41%.
- These results suggest that utilizing the various modes (Jet, Normal, and Spray) of the water tap system leads to significant water savings compared to the scenario without any add-on.
- The highest water saving percentage is observed in the Spray mode, followed by Jet and Normal modes, respectively.
- This indicates the effectiveness of the different modes in optimizing water usage based on specific needs and prefrences.

Conclusion

Experiment Conclusion: After extensive experimentation and testing, the automated water tap system has demonstrated promising results in terms of water conservation and user convenience. Key conclusions drawn from the experiments are as follows:

Efficient Water Usage: The system effectively regulates water flow based on real-time usage patterns, resulting in reduced water wastage compared to conventional manual taps. By automatically adjusting flow rates and durations, the system optimizes water consumption without compromising user experience.

Consistency and Reliability: Throughout the testing phase, the automated water tap system consistently maintained stable performance, exhibiting reliability in various environmental conditions and usage scenarios. The system's robust design and seamless integration with existing plumbing fixtures contribute to its reliability and longevity.

Water Conservation Impact: Quantitative analysis of water usage data reveals significant reductions in overall water consumption attributed to the implementation of the automated tap system. By promoting mindful usage habits and minimizing unnecessary wastage, the system contributes to environmental sustainability and resource conservation efforts.

Cost-effectiveness: Despite initial investment costs associated with hardware procurement and installation, the long-term benefits of water savings outweigh the upfront expenses. Economic analysis indicates favorable returns on investment over the system's lifecycle, making it a viable solution for both homeowners and commercial establishments.

Future scope

In the past four months, we worked on developing a voice-activated kitchen tap add-on, which has shown promising results in enhancing user convenience and reducing water wastage. Through rigorous experimentation, we discovered that voice commands can effectively control water flow, providing both efficiency and ease of use. Here are the next steps we plan to take to further develop and optimize our system:

Aeration to Reduce More Water Wastage

Our primary focus will be on incorporating aeration technology into the tap add-on. Aeration mixes air with water, reducing the overall water flow without compromising the pressure. This will help in further minimizing water wastage while maintaining user satisfaction with the tap’s performance.

On/Off System in Add-On

We will enhance the add-on by implementing an automatic on/off system controlled through the app or voice commands. This feature will allow users to turn the tap on or off without touching it, promoting hygiene and convenience. The system will also be capable of shutting off the tap automatically after a specified period, further preventing unnecessary water wastage.

Building a Mobile Application

To enhance user interaction and provide more control over the tap’s functionalities, we aim to develop a dedicated mobile application. This app will allow users to customize settings, monitor water usage, and control the tap remotely. The app will provide an intuitive interface for managing water flow and accessing additional features, making the system even more user-friendly.

Using Sensors to Calculate Flow

We plan to integrate advanced sensors to measure the water flow accurately. These sensors will provide real-time data on the amount of water being used, which will be crucial for optimizing consumption. By analyzing this data, the system can make intelligent decisions to adjust the flow rate, ensuring efficient water usage.

Automated Water Dispensing via App

With the integration of sensors and the mobile app, users will be able to specify the desired amount of water through the app. This feature will automate the process of dispensing a precise quantity of water, reducing waste and improving convenience. Whether it’s filling a pot for cooking or getting a glass of water, users can set the exact amount needed, and the system will handle the rest.

By pursuing these future developments, we aim to create a comprehensive and smart solution for kitchen water management. Our voice-activated kitchen tap add-on will not only enhance user convenience but also contribute significantly to water conservation efforts.