i17 Practical Course 23SS: Implementation of a Glass-washing Component for Cocktail Machine

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Introduction

In this project, we aim to design and implement an automatic cup-washing module for an existing robot.

The addition of this module will enable the robot to autonomously wash cups by employing a pressure-based cup-washing method. This module comprises several essential components, including a pressure cup-washing washer, water tanks for water supply and waste water storage, a water pump to generate pressure, and a 3D-printed and glued structure to securely hold these components together.

The primary objective of this cup-washing module is to alleviate the burden of manual cup washing in automated settings, where a large number of cups are used daily. The integration of this module with an industrial robot arm ensures precise and consistent cup washing, further enhancing the quality of the overall process.

Moreover, we use several programs BPMN to automate the cup washing process.

1 Physical components

For this cup-washing module to work as intended, we need various physical components to work in harmony. In this section we will list the component that are used.

1.1 Pressued Cup Washer

A pressure-Water cup washer as seen in Figure 1 is needed to accomplish the cup washing task. A structural container is needed to place the cup washer in a steady position.

1.2 Water Supply System

As our robot does not have access to tap water or sewage, the following components are needed for supplying water to and gathering water from the cup washer.

Figure 1: Water Supply System

Figure 2: Water Containers

Figure 3: Water Pump

For supplying clean water to and gather waster water from the cup-washer, we are using portable water containers with taps as seen in Figure 2. Through this way we can easily replace water containers to ensure a steady water supply.

Without pressured water supply from tap, we would need to use a water pump to emulate the water pressure from pipes, so that the cup washer can work has enough pressured water to clean the cups. A 20W small water pump with 5-meter pumping height as seen in Figure 3 is used in this design.

Due to the vulerability of the water pump, and to conserve power, a WLAN-based MQTT Switch is needed for controlling the water pump dynamically according to usage, as seen in Figure 4.

1.3 Structural Support

Using a pre-existing container and a 3D-printed structure, we can put together a structure with steady support for the system. Extra space under the cup washer is needed to ensure the elastic water tubes have enough space and not fold together. Therefore a plastic container with a 3D-printed frame are glued together to provide a stable location for the cup washer. Conveniently, we can attach the water pump to the structure so our components stay close together and becomes easier to manage. As seen in Figure 5, the structural support puts all the components together to form a water supply system.

The 3D-printed frame design can be seen from Figure 6. The design draft is made with online software

Figure 4: Delock MQTT Switch

Figure 5: Full Structural Support for Cup Washer

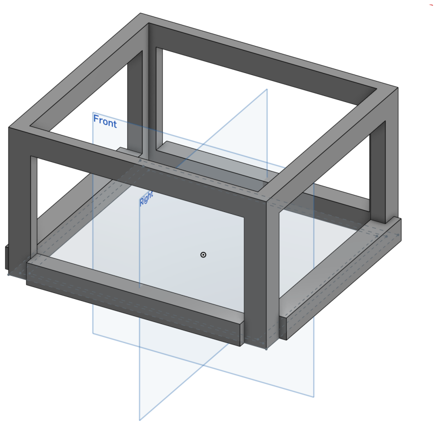

Figure 6: Design for 3D-Printed Frame Extension

OnShape. The file is then ported to **UltiMaker Cura** for post-processing with printing configurations of 30% Density and Zig-Zag pattern. With the exported file, the **AnkerMake M5** printer can start printing with no more human intervention.

2 Installation

The main challenge of this component is to ensure different parts of the system works in harmony. Other than ensuring physical components are connected correctly, we also need to setup the MQTT switch correctly and create the correct program on the server.

2.1 MQTT Switch Setup

After connecting the MQTT Switch to a socket, we need to use the following steps to setup the switch.

1. Quick press the button on the switch 4 times to enable configuration mode.
2. Setup the switch name and topic for the MQTT Broker as "washer".

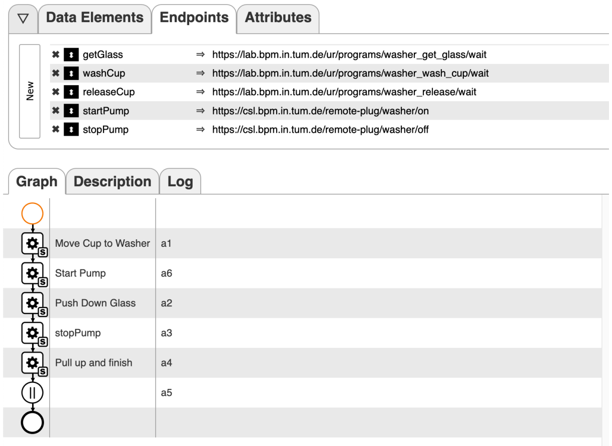

Figure 7: BPMN Graph and Endpoints

3. Connect the switch to the WLAN with the process hub MQTT server. In our case, the WLAN Cocktail_Mixer connects to the MQTT broker on 131.159.6.111:1883.

When setup for the switch is done, we can utilize the existing endpoints on Process Hub to turn on and off the switch with REST API calls.

1. Start Pump with *https://csl.bpm.in.tum.de/remote-plug/washer/on* as *PUT* request
2. Stop Pump with *https://csl.bpm.in.tum.de/remote-plug/washer/off* as *PUT* request

2.2 Robot Programming Setup

Three programs for three steps are prepared for the cup-washing process, accessible with the following REST endpoints with PUT request:

1. Moving glass from start position to cup washer upside down.
   (*https://lab.bpm.in.tum.de/ur/programs/washer_get_glass/wait*)
2. Pressing glass down onto the cup washer and releasing after 10 seconds.
   (*https://lab.bpm.in.tum.de/ur/programs/washer_wash_cup/wait*)
3. Moving glass back to the starting location.
   (*https://lab.bpm.in.tum.de/ur/programs/washer_release/wait*)

3 Process and Programs

The entirety of the robots movement is made possible through BPMN from cpee.org. The graph and endpoint is shown in Figure 7.

The movement process is straight-forward:

1. The *washer_get_glass* endpoint is called. The robot arm will move to initial position and adjust the gripper, grab the glass, turn it upside down, then move it above the cup washer.
2. The *washer/on* endpoint is called. This will turn on the water pump and supply pressued water to the cup washer.
3. The *washer_wash_cup* endpoint is called. The robot arm will press down the glass onto the cup washer. The washer now released pressued water onto the glass and washes it. This process is timed for 10 seconds. Then the robot arm will lift the glass from the washer.
4. *washer/off* endpoint is called. This will turn off the water pump and stop the water supply.

5. The *washer_release* endpoint is called. The robot arm will flip the glass and place it back to the starting location.

The video of a successful run is available in this link as well as the GitHub repository for related source files.

4 Possible extensions

1. Using customized structure for cup washer and water supply system. Currently the water supply container is placed next to the structure in an arbitrary position. With a better designed integrated contraption, the cup washer can be integrated to the corners of the table on table-level height, further improving the stability and accessibility of the component. With a better positioning of the water container, we can also achieve a higher water pressure for better cleaning results.

2. Implement a water-level monitoring system to automatically notify managers when supply container is close to empty or the waste container is close to full. This can be possibly achieved by pressure sensor or simply based on usage calculation.

3. Implement different cleaning modes with either longer wash times or different water pressure settings. These modes can be activated based on the properties passed from the endpoint, to facilitate different levels of cleaning needs.