MONITORING APPLIANCE ENERGY CONSUMPTION

TEAM 33

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MOTIVATION

PROBLEM STATEMENT AND SCOPE

THE GOAL OF OUR PROJECT IS TO COLLECT CURRENT SIGNATURES OF UNKNOWN APPLIANCE STATES AND CLASSIFY THEM INTO A KNOWN STATE, FOR EXAMPLE, STATES LIKE RINSE, WASH, DRAIN, ETC. FOR A WASHING MACHINE.
KEEPING AN EYE ON MACHINE LEARNING ALGORITHMS AND OTHER CLASSIFICATION METHODS. WE HAVE CREATED A PIPELINE TO ACCOMPLISH THIS IN ORDER TO

- COLLECT TIME SERIES CURRENT SIGNATURE OF A PARTICULAR DEVICE IN A ROBUST AND SECURE MANNER
- DETECT APPLIANCES FROM THEIR CURRENT CONSUMPTION SIGNATURES USING INTRUSIVE LOAD MONITORING ALGORITHMS AND MACHINE LEARNING CLASSIFICATION TECHNIQUES WITH MINIMUM LATENCY
- CREATING A DASHBOARD WHERE THE USER CAN SEE THE PREDICTED LABEL FOR HIS/HER STATE OF THE DEVICE WITH OTHER STATISTICS AND MONITOR THE ENERGY CONSUMPTION OF THE STATE.

WE ALSO LOOK FOR PATTERNS IN THE CURRENT SIGNATURES OF VARIOUS DEVICES AND OFFER OUR BEST GUESSES AS TO HOW WELL THE MODEL WILL WORK.

PURPOSE OF THE SYSTEM

THESE DAYS, THERE IS A RENEWED INTEREST IN FINDING MORE EFFECTIVE WAYS TO USE ENERGY DUE TO THE THREAT OF RISING ENERGY COSTS AS WELL AS WORRIES ABOUT ITS AVAILABILITY AND ENVIRONMENTAL EFFECTS.

AN ACCURATE DEVICE DETECTION TECHNIQUE AND AN ENERGY MONITORING PRODUCT WILL BE ABLE TO PERFORM THE FOLLOWING:

- LOCAL ENERGY CONSUMPTION UNDERSTANDING: HERE, THE GOAL IS TO GIVE THE HOUSEHOLD ENERGY FEEDBACK ON JUST ONE APPLIANCE. INSIGHTS INTO USE, PATTERNS, AND TRENDS WILL BE INCLUDED IN THIS, WITH THE GOAL OF CREATING OPPORTUNITIES TO LOWER ENERGY EXPENDITURES AND USAGE.
- APPLIANCE MONITORING: DETECTING ABNORMAL ELECTRICITY CONSUMPTION, DEVIATION OF CONSUMPTION OR FAULTY DEVICES

MANY PEOPLE CONCENTRATE ON OPPORTUNITIES THAT CALL FOR CUTTING-EDGE NEW SYSTEMS OR ON ENERGY-SAVING MEASURES THAT LESSEN THEIR BENEFITS. HOWEVER, THERE IS ENORMOUS POTENTIAL TO DECREASE ITS CONSUMPTION AND LOWER ITS OVERALL COST BY SIMPLY ALTERING OUR OWN USAGE PATTERNS.

HARDWARE

ESP32 BOARD

WE HAVE USED THE FOLLOWING PINS OF THE MICROCONTROLLER:

- 3.3 V: USED FOR POWERING THE SENSOR
- GND: USED FOR THE GROUND CONNECTION
- PIN D34: USED FOR READING THE OUTPUT

WCS1800 35A CURRENT SENSOR

CURRENT SENSING IS MADE POSSIBLE BY THE SPECIAL PACKAGE, WHICH MAKES IT SIMPLE TO IMPLEMENT WITHOUT CAUSING THE ORIGINAL SYSTEM TO MALFUNCTION. MOTOR CONTROL, LOAD MANAGEMENT, OVER-CURRENT FAULT DETECTION, AND ANY INTELLIGENT POWER MANAGEMENT SYSTEM ARE EXAMPLES OF TYPICAL APPLICATIONS. IT IS A HALL EFFECT BASED CURRENT SENSING SENSOR WHICH OUTPUTS A VOLTAGE PROPORTIONAL TO THE INPUT CURRENT.

THE DEVICE WHOSE SIGNATURE NEEDS TO BE COLLECTED CAN BE PLUGGED INTO THE SOCKET THAT HOUSES THE SENSOR, WHICH IS ENCLOSED WITHIN IT.

- A BOX PROVIDED TO US CONTAINING THE CURRENT SENSOR

- A 3D BOX MODELLED AND PRINTED BY US TO STORE THE PCB AND ESP32

METHODOLOGY

THE WORKFLOW CAN BE DIVIDED INTO SEVERAL STEPS:

- **PROPOSING A SENSOR AND TESTING THE RECEIVED SENSOR**: WE HAD INITIALLY SHORTLISTED VARIOUS SENSORS. FINALLY, WE USED THE ONE PROVIDED BY THE COLLEGE. AFTER RECEIVING THE SENSOR, WE TESTED IT ON VARIOUS DEVICES TO INSPECT SENSIBLE OUTPUTS.
- **CALIBRATION OF THE SENSOR AND CIRCUIT DESIGN**: WE CALCULATED MULTIPLE TIMES QUIESCENT VOLTAGE AND THEN TOOK THEIR AVERAGE TO GET OUR VOG. THEN WE PASS THROUGH THE SENSOR A KNOWN CURRENT AND GET VRMS AND DIVIDE IT BY SENSITIVITY OF OUR SENSOR TO GET THE CURRENT VALUE AT THAT POINT FOR THE APPLIANCE.

- DESIGNING PREDICTION PIPELINE, INTEGRATING IT WITH THE MODEL AND CONNECTING IT TO THE DASHBOARD:
  - THE COLLECTED SENSOR DATA IS SENT ON THINGSPEAK AS WELL AS ON OM2M COLLEGE SERVER .
  - HERE, WE CREATED A PIPELINE OF SECURE DATA TRANSFER FROM
    (ESP32 → oneM2M → ML Model → Flash dashboard).

DATA VALIDATION AND DEPLOYMENT CAMPAIGN

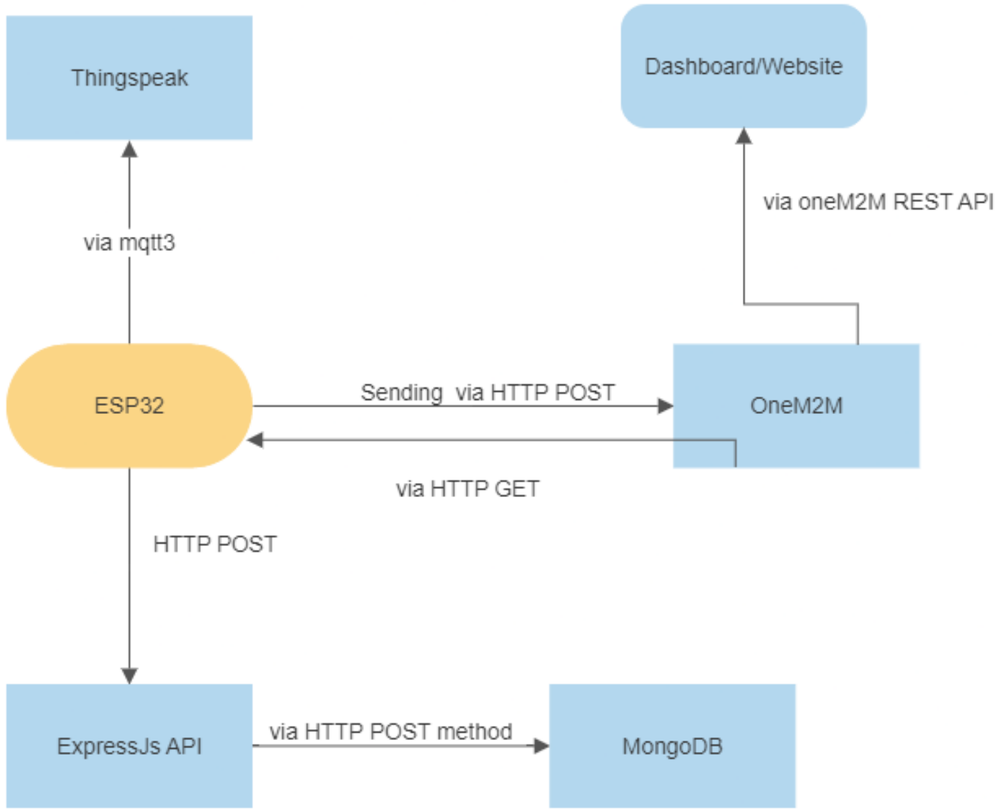
WE CHECKED THE SENSORS PROVIDED TO US FOR KNOWN INPUTS.
SENSITIVITY OF THE SENSORS WAS MEASURED AND THE SENSORS WERE CALIBRATED ACCORDINGLY.

DATA COLLECTION

THE DATASET BUILDING FOR PREDICTING THE DEVICE STATE HAS TO BE DONE BY EXHAUSTIVE COLLECTION AND ANALYZING:

- THE SENSOR POST CALIBRATION, WAS PUT TO DATA COLLECTION PURPOSES, WHERE IT USED TO SEND IT'S DATA COLLECTED TO A MONGODB, USED FOR STORAGE. BY MAKING TUPLES UNIQUE AND ADDING IDENTITY PARAMETERS, WE COULD ACTUALLY TAKE DATA INPUTS OF ALL FOUR DEVICES TOGETHER. BECAUSE, MONGODB DOESN'T HAVE DIRECT APIS TO PUSH DATA FROM C++, WE DID IT BY CREATING A BACKEND SERVER HOSTED FOR THIS JOB. IT WAS MADE USING NODEJS, AND PROVIDED API CALLS, TO SEND DATA DIRECTLY TO MONGODB, WITH ALMOST NEGLIGIBLE DELAY. THIS ALLOWED TO MAKE AN EXTENSIVE DATASET WITH AMPLE OF DATA POINTS.

DATA FLOW DIAGRAM



DATA VISUALISATION AND ANALYSIS

REAL TIME GRAPH OF THE CURRENT VALUES, AND THE PREDICTION OF THE STATE IS PRINTED ON A LOCALLY HOSTED WEBPAGE

MACHINE LEARNING MODELLING

ALGORITHM USED

CONVOLUTIONAL NEURAL NETWORK IS USED. IT IS A DEEP LEARNING NEURAL NETWORK ALGORITHM WHICH TAKES IN AN INPUT AS A IMAGE OR A MULTIVARIATE TIME SERIES AND IS ABLE TO SUCCESSFULLY DETECT AND ANALYSE THE PATTERN IN THE TRAINING SET. IT IS COMPOSED OF 3 DIFFERENT LAYERS.

LAYERS OF A CNN

COMPOSED OF 3 LAYERS:-

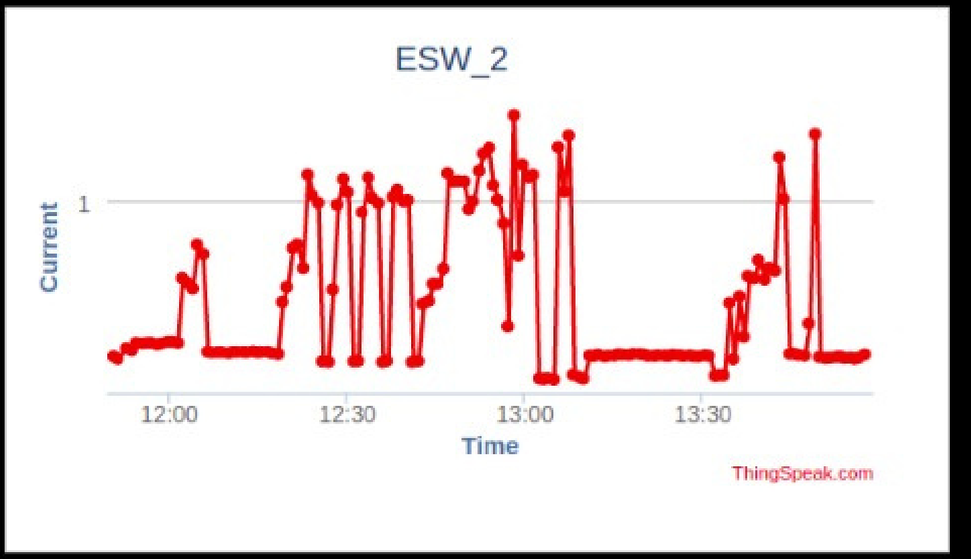
1. CONVOLUTIONAL LAYER: PERFORMS CONVOLUTION OF AN INPUT SERIES OF FEATURE MAPS WITH A FILTER MATRIX.
2. POOLING LAYER: GOAL OF THIS LAYER IS DIMENSION REDUCTION OF THE FEATURE MAP WHILE RETAINING MOST OF THE DATA.
3. FULLY CONNECTED LAYER: GOAL OF THIS LAYER IS TO LEARN NON-LINEAR COMBINATIONS OF HIGH-LEVEL FEATURES REPRESENTED BY OUTPUT OF ABOVE 2 LAYERS.

CONCLUSION

THE FINAL PRODUCT OF THE PROJECT IS AN ENERGY CONSUMPTION MONITORING AND VISUALISING DASHBOARD, WHICH CAN ASSIST THE USER IN KEEPING TABS ON THE APPLIANCE'S ENERGY CONSUMPTION AND TAKING THE APPROPRIATE ACTION IN THE EVENT OF AN UNEXPECTED ENERGY CONSUMPTION VALUE. THE ML MODEL IMPLEMENTED FORCASTS THE APPLIANCE BEING USED AND TRACK THE PORT'S INTERMITTENT AVAILABILITY.

Appliance Energy Monitoring

Live Sensor Data



Predicted State:

Current Value - 1.3419 -----> MODE 1

WASHING / SPIN

THANK YOU