Precision Livestock Farming

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1. Problem statement

- ➔ Broiler chicken are prone to mass casualty and disease outbreaks leading to economic loss for the farmers
- ➔ No significant symptoms behind these incidents
- ➔ Broiler chicken are made to grow fast, oftentimes unable to support its own weight
- ➔ Leg disorders and paralysis are a major cause of poor welfare in broilers

2. Objectives

- ➔ To minimize disease outbreaks among broiler chicken,
- ➔ To raise business profile of poultry farmers by reducing loss due to mass casualty
- ➔ Create feasible environment for the growth of broiler chicken according to age
- ➔ Determine and analyze fowl behaviour (feeding, mobility, distribution, etc) to determine their health condition
- ➔ Alert farmers when fowl need their attention
- ➔ In the long run, meet growing demand for poultry meat

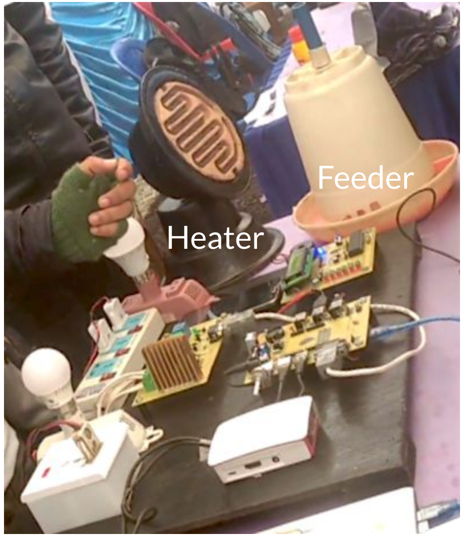
3. Project Overview

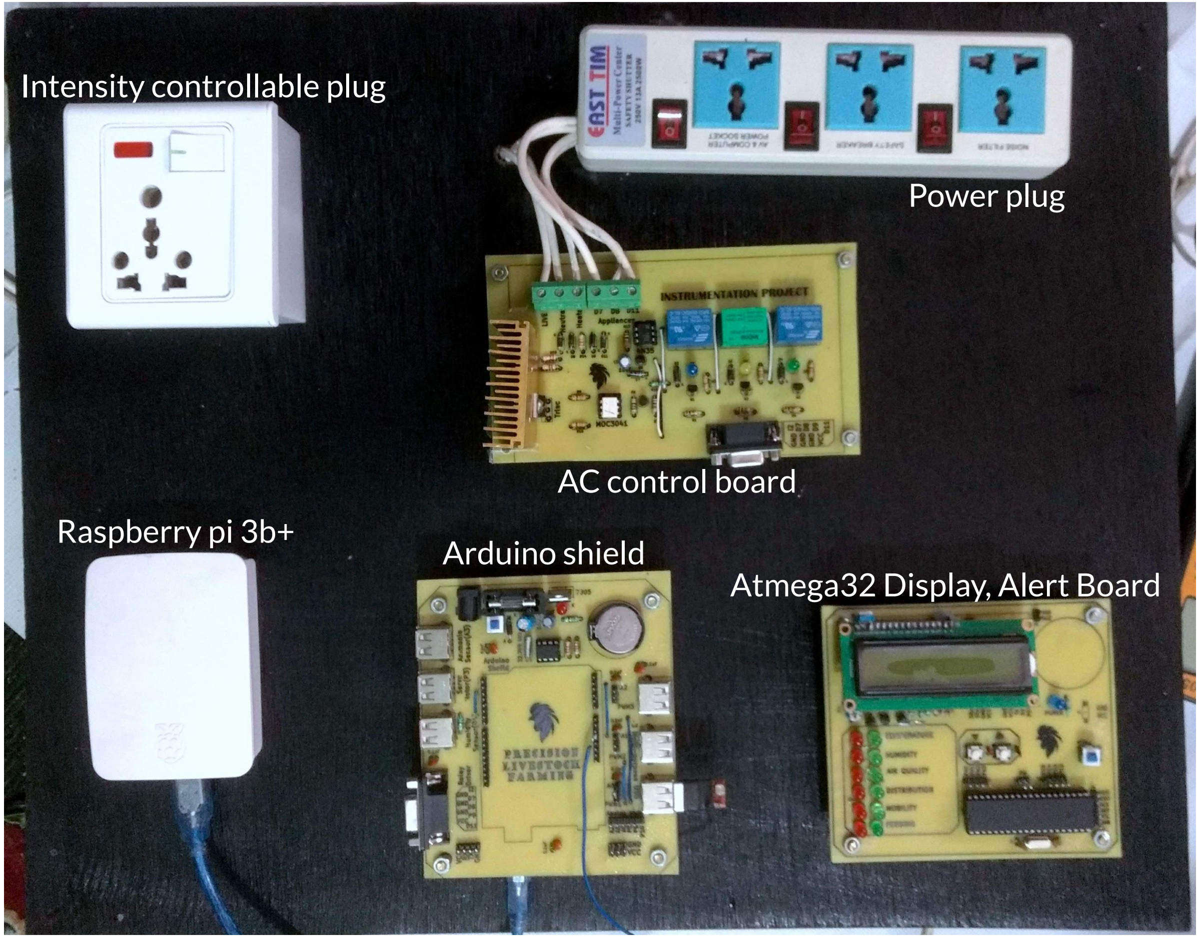
➔ Precision Livestock Farming (PLF) uses advanced technologies to optimize throughput of an individual or a group of animals by continuous monitoring of their health, production (animal products) and environment

➔ Our prototype, which tracks whole flock as one organism is built for broiler farms

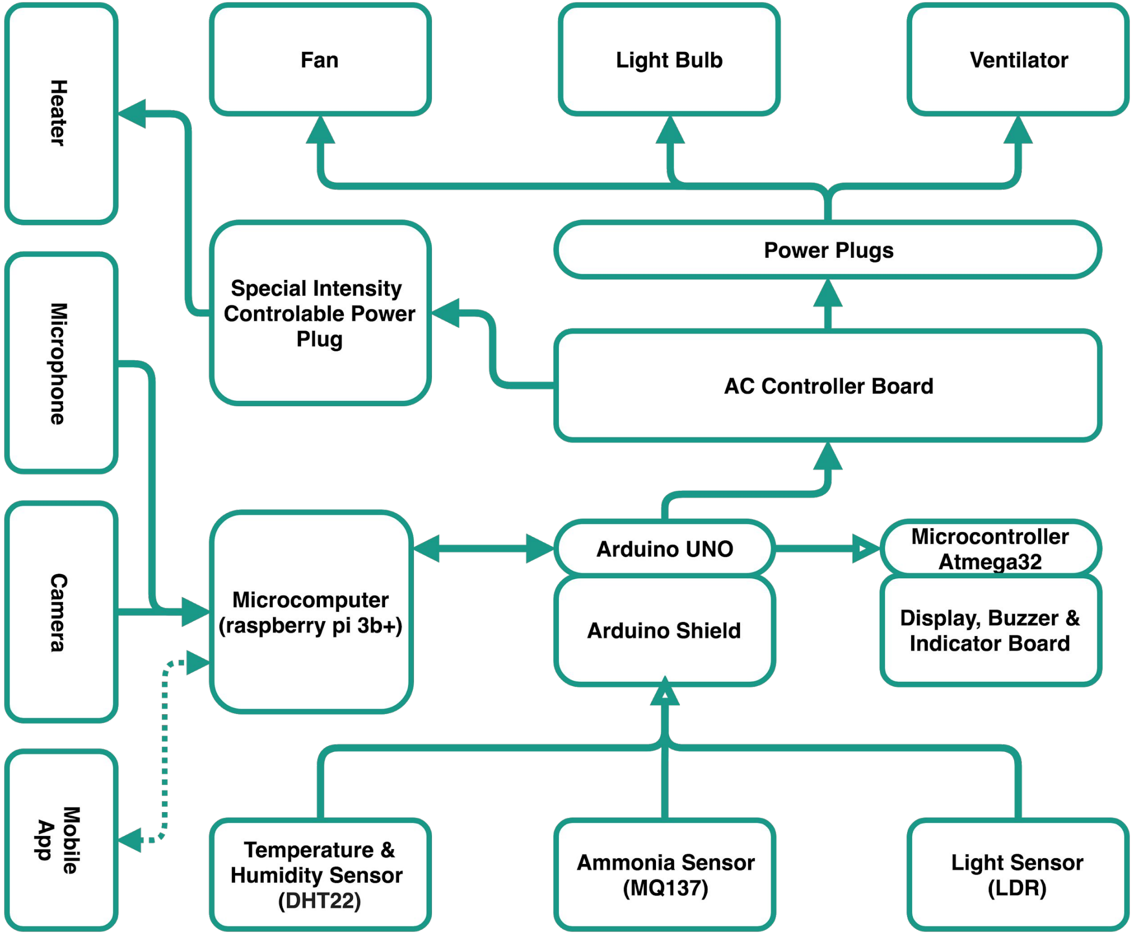
➔ Camera, microphone and environmental sensors (light, ammonia, humidity and temperature) are used for monitoring

➔ The monitored behaviour is compared with normal behaviour to take further action required





3.1 Picture of Prototype



3.2 Physical architecture of prototype

3. 2.1 Temperature & humidity Sensor (DHT22)

- ➔ Measures temperature and relative humidity in the farm
- ➔ Lower rearing temperature results in higher mortality
- ➔ High humidity during brooding period favor growth and feed conversion but such habitat can cause some disease

3. 2.2 Ammonia Sensor (MQ137)

- ➔ Majority of ammonia gas is originated from the excreta of fowls
- ➔ Ammonia gas in poultry severely affects the health (such as cause bacterial respiratory infection, reductions in body weight, etc) of chickens

3. 2.3 Light Sensor (LDR - Light Dependent Resistor)

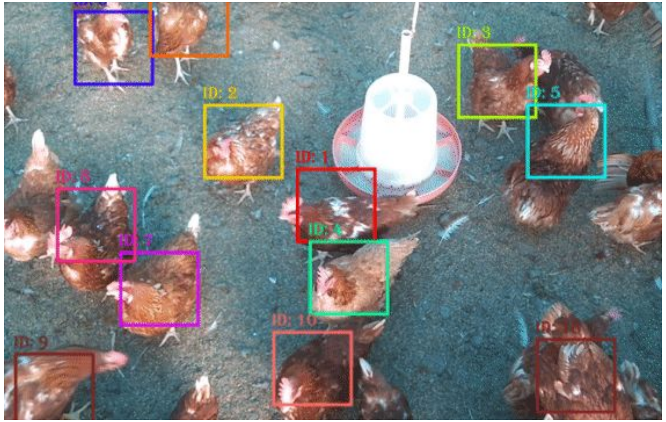
- ➔ Measures light intensity
- ➔ However light intensity has no significance on broilers' welfare
- ➔ Used for automatic lighting system

3. 2.4 Microphone

- ➔ Placed under each feeder
- ➔ Audio signal (pecking recording) is processed to calculate peck count
- ➔ Peck count is converted to feed intake of chicken in real time
- ➔ Finally feeding behaviour is determined
- ➔ Normal daily feed intake of a broiler chick per day (gm) is approximated by
  FD= 0.37 + 3.546(A)
  A is age of broiler in days (Brake et al., 1992)

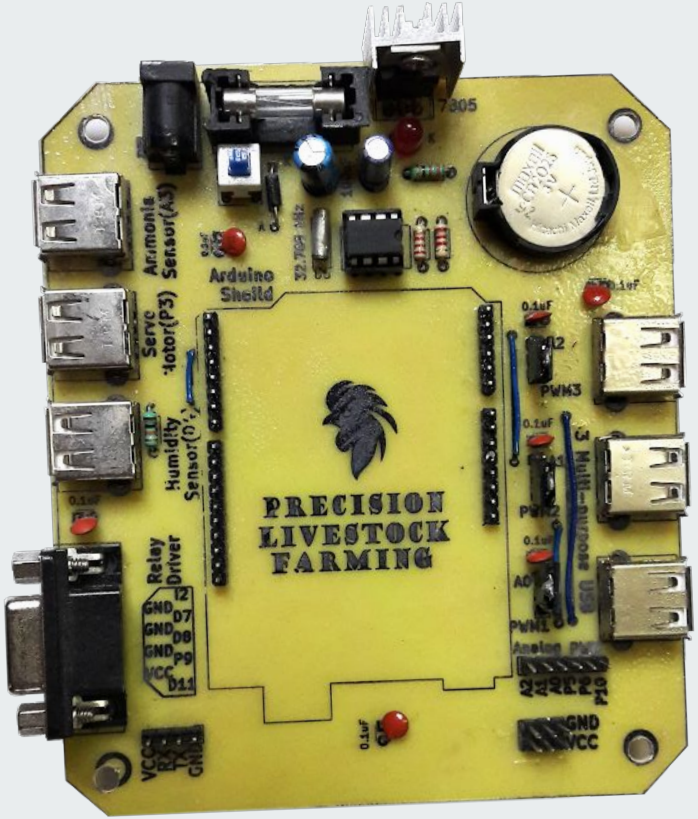
3. 2.5 Camera

➔ Placed to get a top view of the farm
➔ Every chicken is detected & tracked on the video
➔ Distribution and mobility index of chickens are calculated from it
➔ Anomalies in distribution index implies ventilation failures, illumination changes and feeding problems
➔ Spatial distribution indicates thermal welfare (Vilas, 2017)
➔ Abnormal mobility index reveals locomotive issues, lameness (paralysis), leg disorders
➔ YOLO trained on broiler image dataset detects the fowl
➔ SORT (simple online real time tracker) identifies & tracks each fowls with an ID



3. 2.6 Arduino Shield & Arduino uno

- ➔ Interfaces environmental sensors
- ➔ Sends sensor data to raspberry pi
- ➔ Receives distribution, mobility index and feed intake data processed from raspberry pi
- ➔ Accepts commands from raspberry pi to control appliances (fan, ventilator, bulb and heater) and further commands AC controller board with signals to turn on or off the appliances
- ➔ Delivers all relevant data to Atmega32 for display purpose



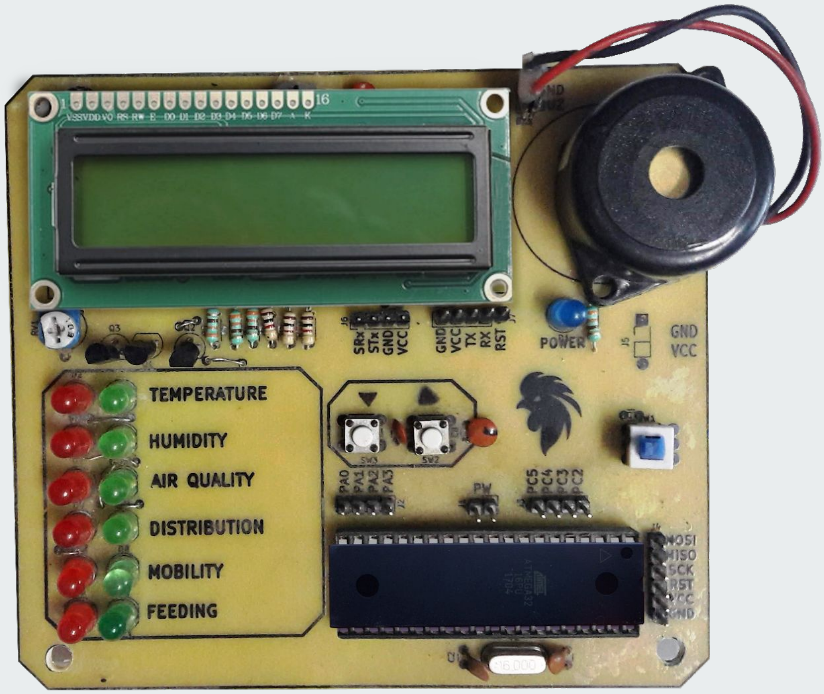
3. 2.7 Atmega32, display, buzzer & indicator board

➔ Collects environmental sensor data, distribution, mobility, feed intake, status of appliances and state of each parameters

➔ Present data from LCD

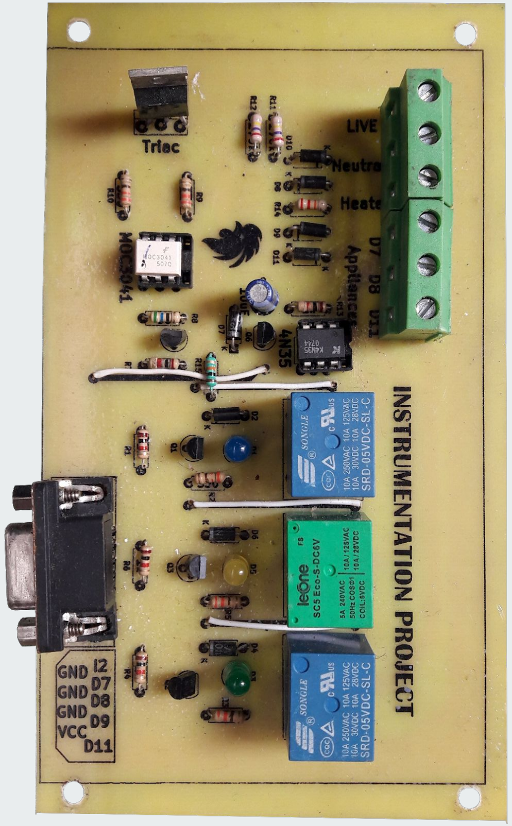
➔ Signals whether a parameter is in normal or critical situation with green or red LED lights respectively

➔ Alert farmers in anomalous conditions



3. 2.8 AC controller board and power plugs

- ➔ It switches relay, based on the signal command to drive ac appliances
- ➔ Uses optocoupler (which isolates circuits by using light) to isolate dangerous ac from sensitive dc components
- ➔ Generates variable ac power flow with triac by changing firing angle



3. 2.9 Special intensity controllable power plug and heater

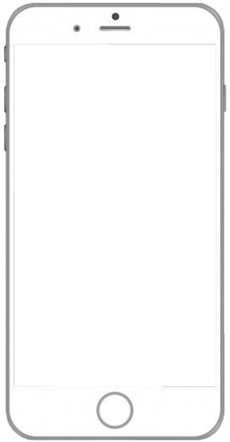
- ➔ Provides variable power to the appliance
- ➔ Connected to heater to control heating intensity
- ➔ Heater maintains indoor temperature

3. 2.10 Fan, ventilator and light bulb

- ➔ Fan & ventilator sweeps harmful gases and fairly maintain humidity
- ➔ Light bulb is utilized when light intensity inside the farm is low

3. 2.11 Mobile App

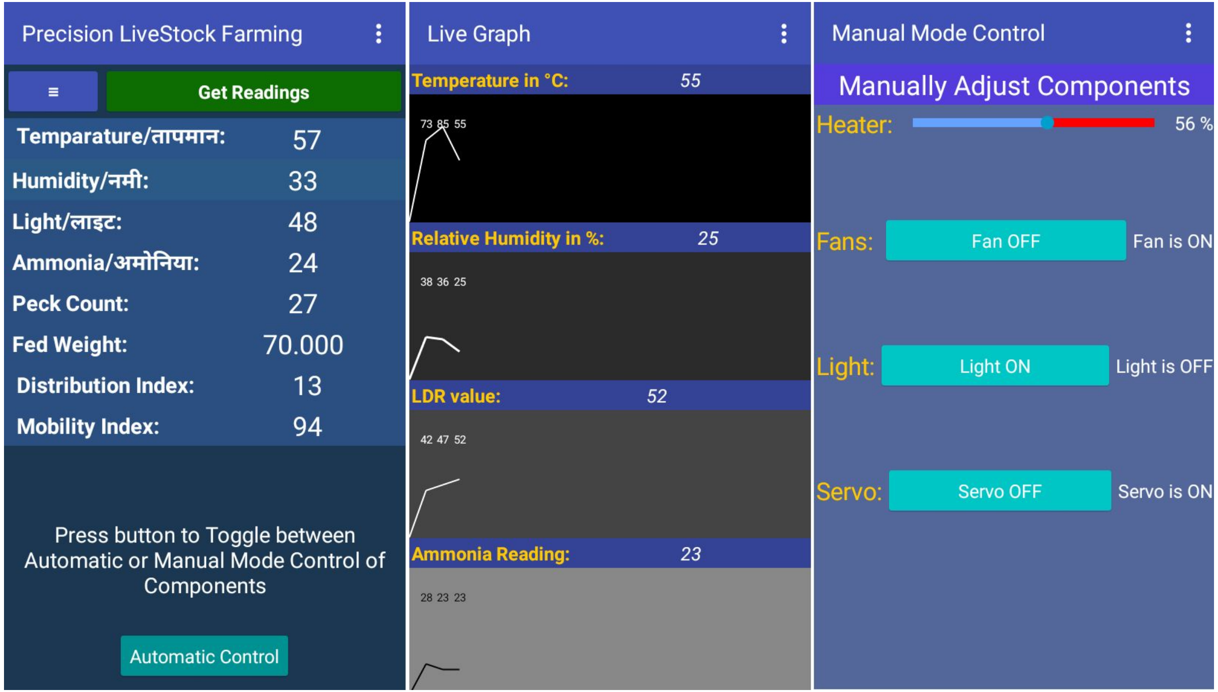
- ➔ Connects to the computer (server) through wifi
- ➔ Can remotely view and control all realtime data and commands



3. 2.12 Microcomputer (raspberry pi 3b+)

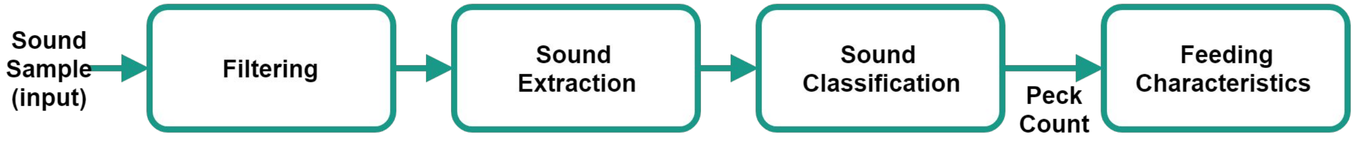
- ➔ Processes video stream and audio recording from camera and microphone respectively
- ➔ Receive all environmental sensor data
- ➔ Creates a server for mobile app
- ➔ Resolves the state of parameters (normal or critical)
- ➔ Takes a decision to turn on/off appliances based on real time data and state of parameters during auto mode
- ➔ Forwards all relevant data to arduino uno

Mobile app screenshots



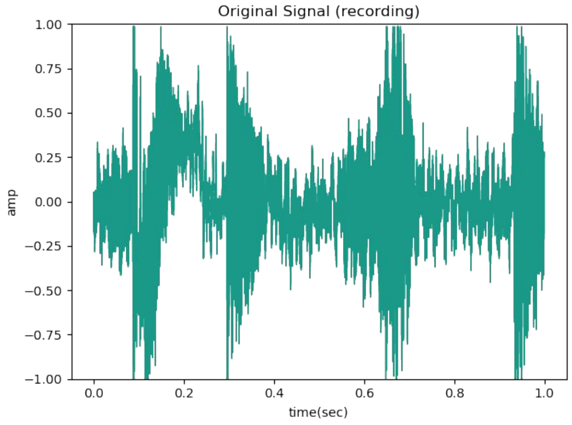
4. Sound Analysis for Feeding Behaviour

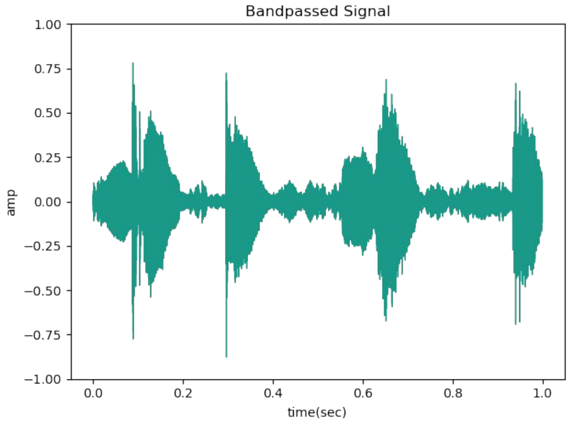
- ➔ Detects pecks in given audio signal
- ➔ This technique is highly adopted from (Aydin et al., 2014)
- ➔ “Pecking sounds were correctly identified with 93.0% accuracy ” (Aydin et al., 2014)
- ➔ This approach is cheaper than using weighing scale
- ➔ General overview of sound analysis, illustrated below



4.1 Filtering

➔ Eliminates low and high frequency noise
➔ Signal is band pass filtered with 6th order Butterworth filter and cut-off frequencies of 2 and 5 kHz



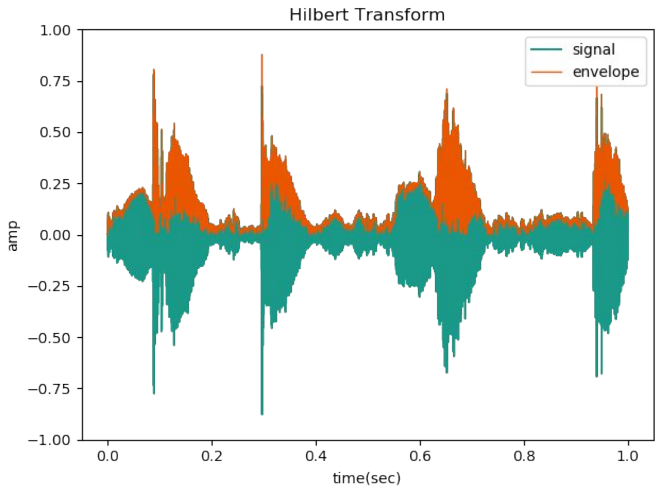


4.2 Sound Extraction

- ➔ Individual peak sound are extracted from recording for further classification of peaks
- ➔ Based on the envelope of the signal and an adaptive threshold
- ➔ Adaptive threshold was chosen instead of fixed because signal was not stable
- ➔ Sound extraction is performed in following steps

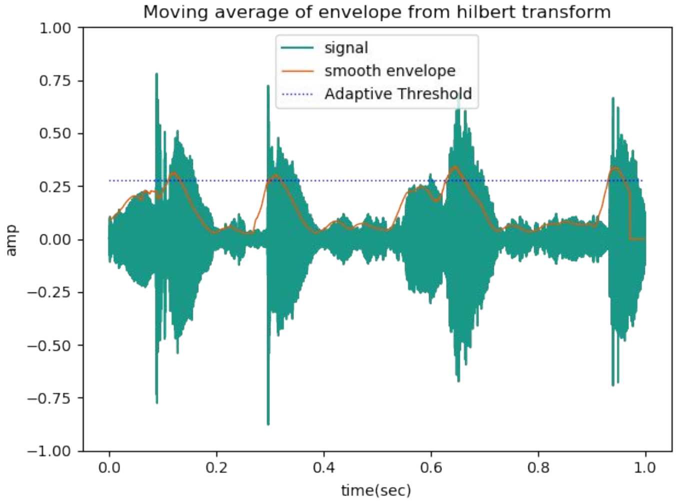
4.2 .1 Hilbert transform of recording

- ➔ Used for envelope detection of recording signal



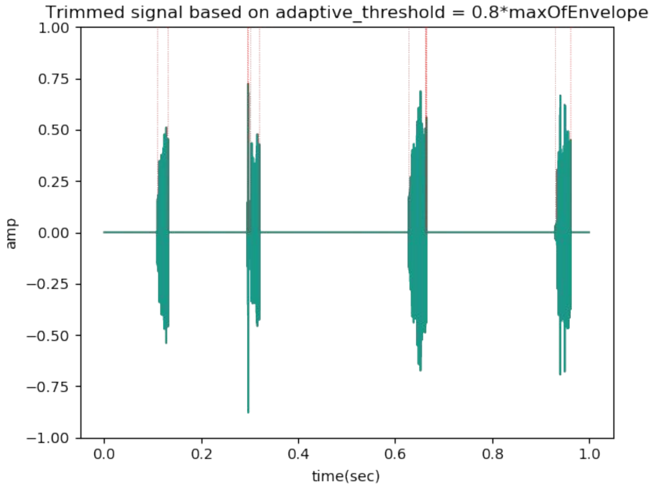
4.2 .2 Moving average of envelope

➔ Envelope from hilbert transform is fuzzy
➔ Moving average smooths out the envelope



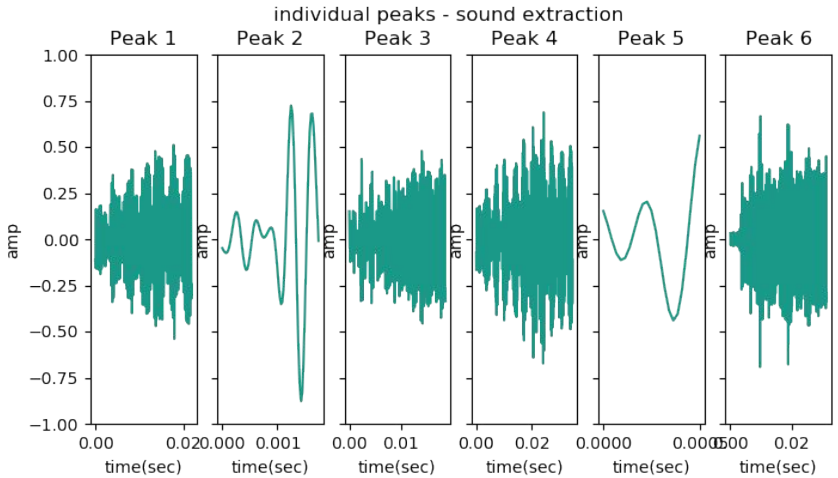
4.2 .3 Trim signal based on threshold

➔ Signal-envelope less than threshold are trimmed



4.2 .4 Split individual peaks

- ➔ Finally, peaks are split
- ➔ These peaks are possible peck sounds

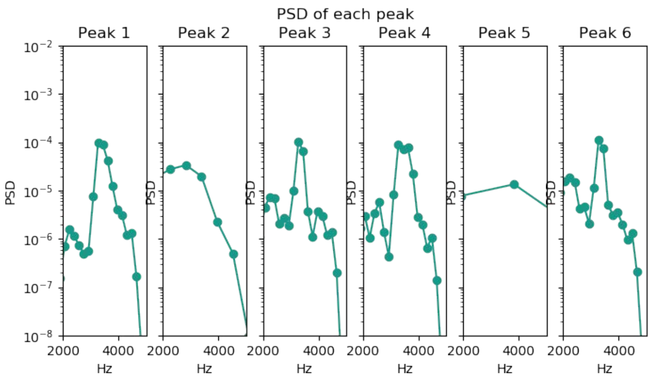


4.3 Sound classification

- ➔ Each peaks are classified as either a peck or other sound
- ➔ It is based on the energy of each peaks and an adaptive threshold
- ➔ Classification is performed in following steps

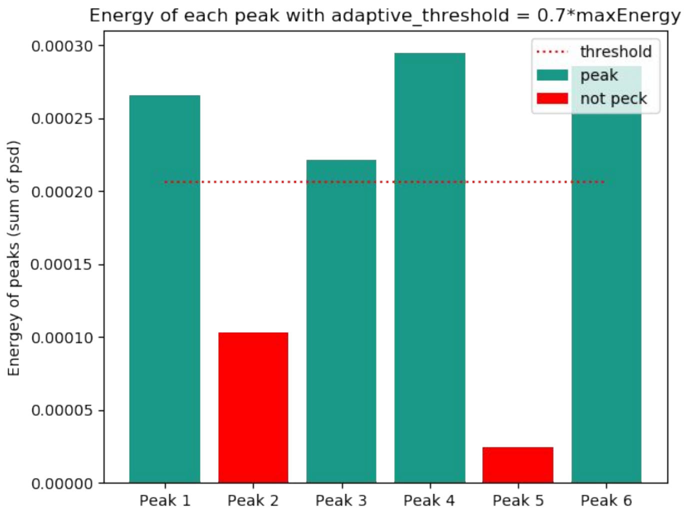
4.3 .1 Power Spectral Density (PSD) for each peak

- ➔ PSD describes distribution of power into frequency components composing the signal
- ➔ Calculated on a frequency range between 2 to 4 kHz



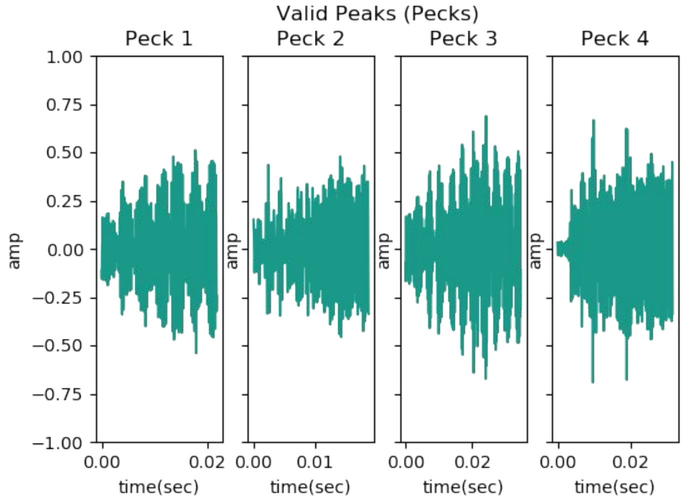
4.3.2 Sum of PSD vector for each peak

- ➔ It gives you the energy of signal (parseval relation)



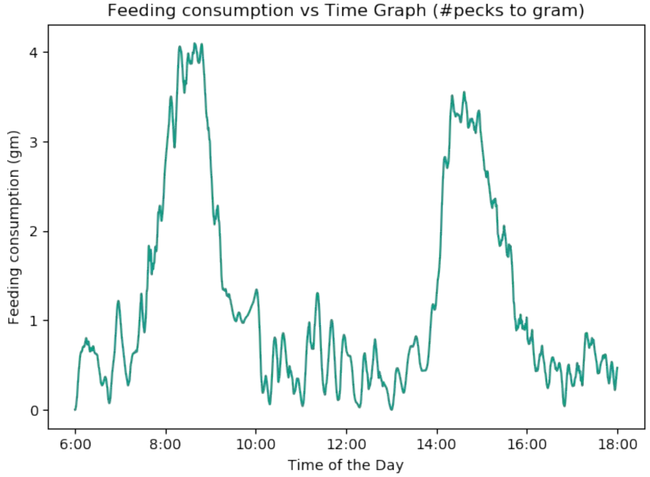
4.3 .3 Valid peak (pecks)

- ➔ Peaks with energy greater than threshold is considered as peck sound
- ➔ Finally peck count is determined



4.4 Feeding characteristics

- ➔ By estimation 1 peck ≡ 0.025gm
- ➔ Feed intake throughout the day in a farm was measured for feeding characteristics



5. Communication

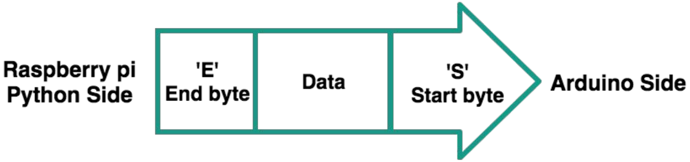
- There are 3 autonomous devices (raspberry pi, arduino-shield and atmega32 display board)
- These devices need communication protocol to share updates between them
- Raspberry pi and arduino perform two way UART communication
- Arduino and atmega32 display board communicate with softwareserial

5.1 Communication between raspberry pi and arduino

5.1 .1 Raspberry pi as transmitter

➔ Packs distribution, mobility index, fed intake commands & status of parameters to transmit as C++ structure (binary form)

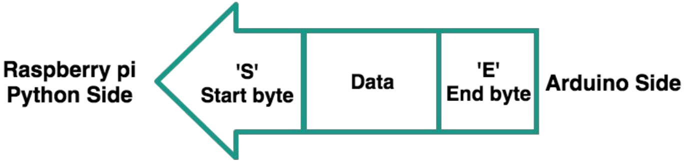
➔ Uses ‘S’ and ‘E’ byte to indicate start and end of packed data



5.1.2 Arduino as transmitter

➔ Uses the S and E characters to denote the beginning and end of the message

➔ Encapsulates the data (temperature, humidity, ammonia and light) to transmit in a C++ structure



5.1.3 Raspberry pi as receiver

➔ Python script unpacks the corresponding encapsulated structure

5.1.4 Arduino as receiver

➔ Packed data is decoded using native serial communication pins (0 & 1)) of arduino

5.2 Communication between Arduino and atmega32

➔ Arduino with native serial communication pins supports serial communication with a piece of chip called UART

➔ Softwareserial allows serial communication on other digital pins of the Arduino, if the native pins are busy

➔ Arduino packs environmental sensor data, distribution, mobility, feed intake, state of appliances & status of parameters and transmits it to atmega32.

➔ Atmega32 receives and unpacks

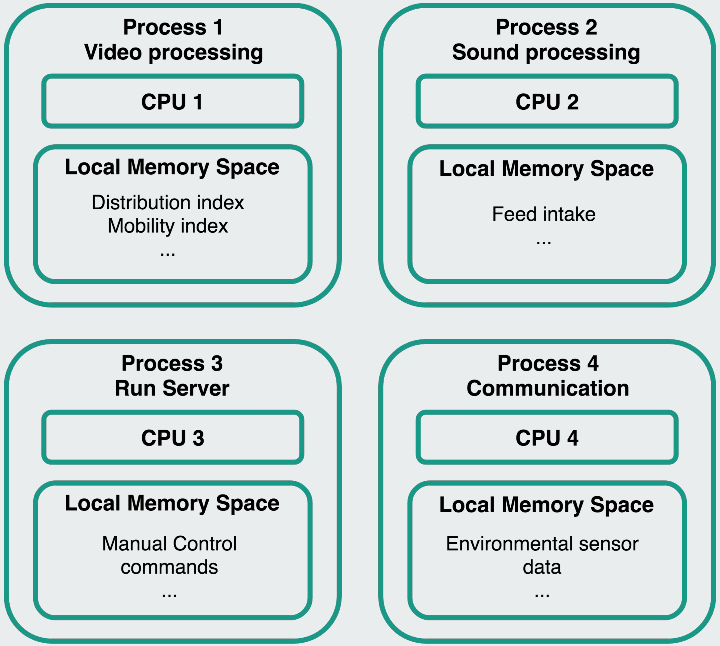
6. Multiprocessing

➔ Allows two or more CPU cores to perform independent task/process parallely

➔ Our project requires microcomputer to perform 4 major tasks endlessly without any returns

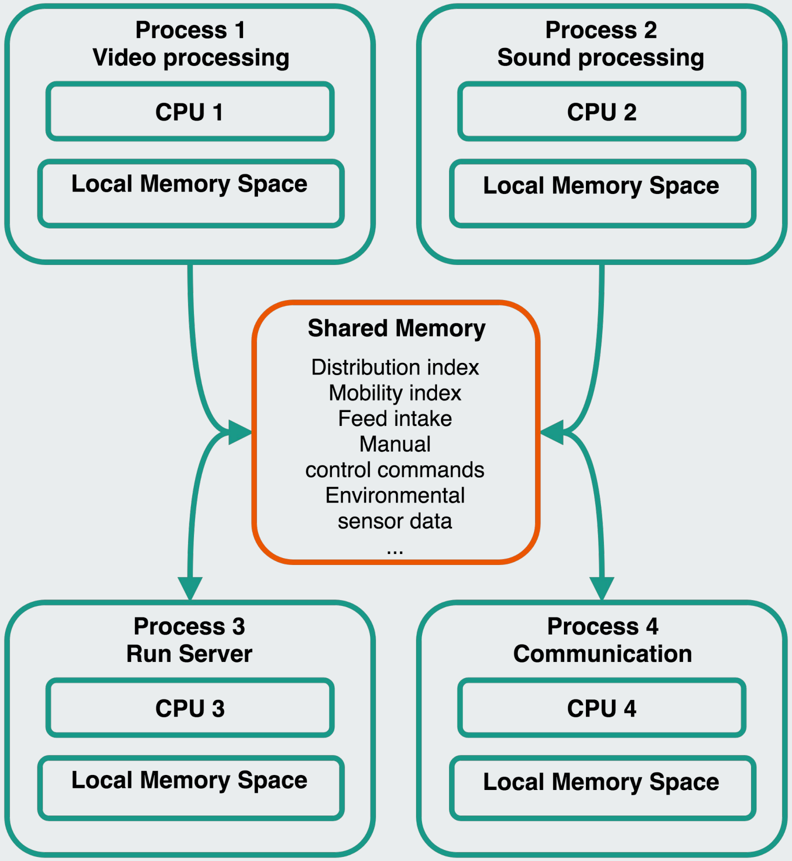
- Video processing
- Sound processing
- Run server
- Communication

➔ Raspberry pi 3b+ has quad core processor, enough to run all 4 tasks simultaneously



6.1 Interprocess communication (IPC) (data sharing)

- Each process has its own memory space
- Thus, program variables (data) aren't shared between processes
- IPC provides an interface to share data among processes
- There are many methods to IPC
- Shared memory is one of the methods
- It allows the interchange of data through a defined area of memory



6.1.1 Need for IPC in the project

- ➔ Communication process requires access to the distribution, mobility index, feed intake, manual control commands, state of appliances and status of parameters to transmit the information to Arduino shield, which in turn updates display board and commands AC board
- ➔ Server requires access to distribution, mobility index, feed intake and environmental sensor data to pass on to the mobile app
- ➔ These processes need access to data they don’t own in their local memory space
- ➔ IPC allow to share data between such processes

7. Future enhancement

- ➔ Deploy project to the web server such that the present processing limit of raspberry pi is overcome and farmers would be able to access data of their poultry farm from anywhere in the world
- ➔ At the moment our prototype tracks the whole flock as one organism. Once we overcome limited processing power of raspberry pi, we plan to monitor each and every fowl in the farm
- ➔ Poultry is one of the contributing areas for the growing problem of antimicrobial resistance in Nepal. Our project can help prevent outbreak of diseases and introduce timely intervention that can minimise unnecessary antibiotic administration
- ➔ Work to improve analysis aspect of the project by conducting studies and consulting farmers

8. References

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