Smart Cradle System for Automated Baby Monitoring

Final Presentation

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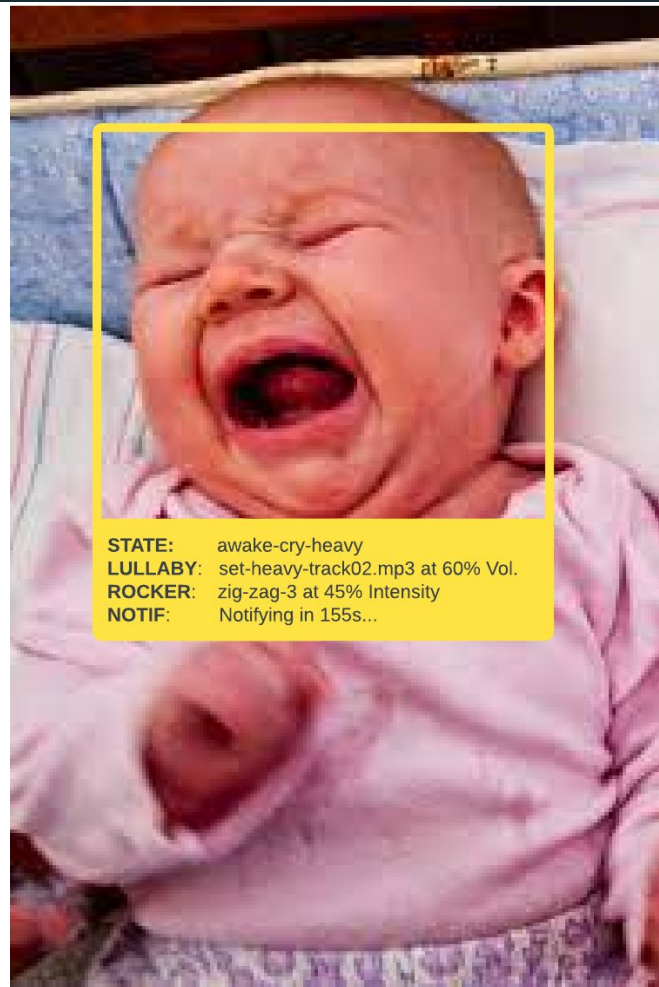SK Sadia Tasnim 1930921

The Idea

- Responding to newborns waking up in the middle of the night is a major hassle.

- Parents of newborns lose 6 months of sleep during the first 24 months of parenting [1].

- Sleep deprivation has adverse health effects on adults.

- Babies left unattended to cry for prolonged periods may lead to undue amounts of stress [2].

- What if we could leverage AI to detect the baby's current mood?

- What if the cradle could accurately respond to the baby's needs?

- A smart cradle would greatly reduce the load on new parents.
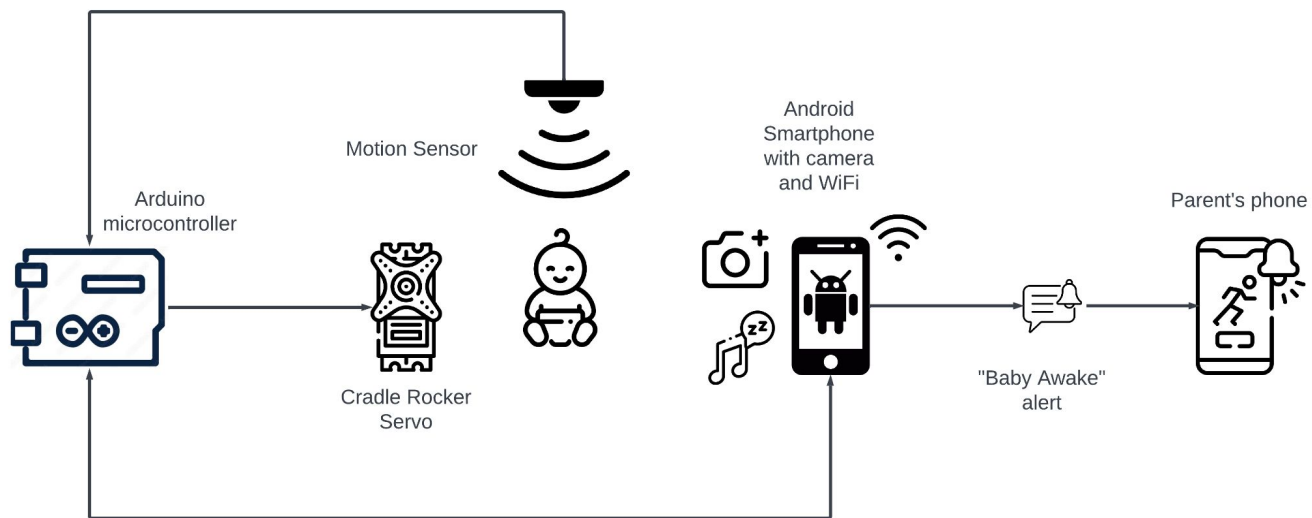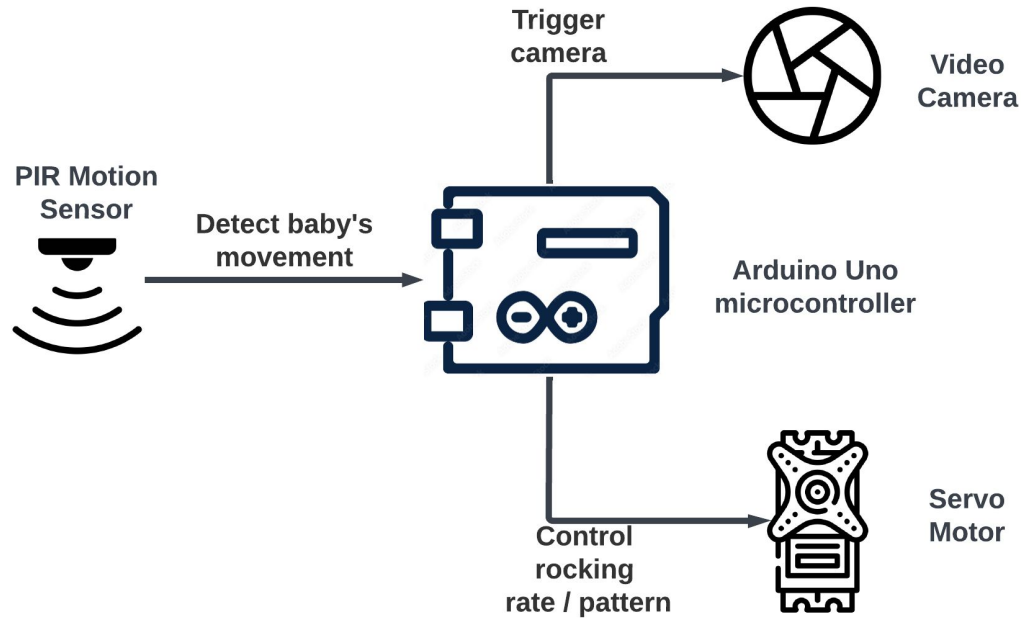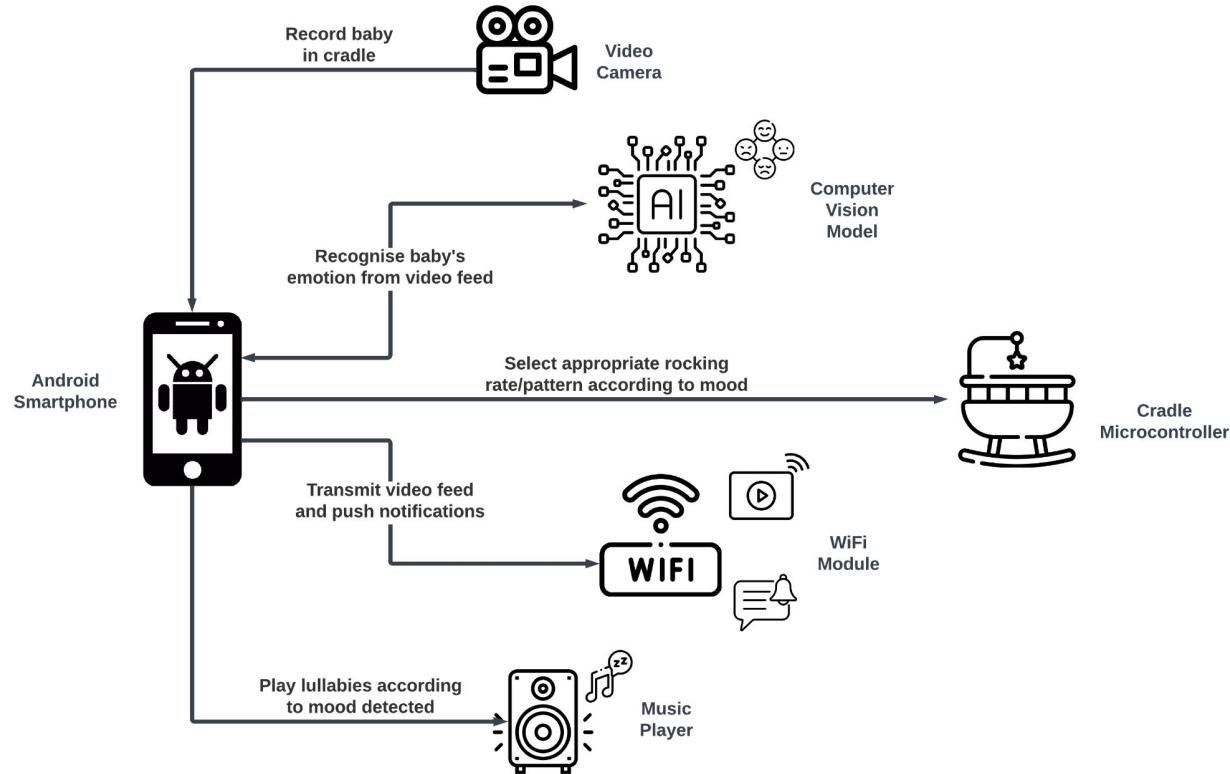
- The result: sleep for all.

[1] https://www.medicalnewstoday.com/articles/195821
[2] https://www.nct.org.uk/baby-toddler/crying/it-ok-let-baby-cry

A Simulated Demo

STATE: awake-cry-heavy
LULLABY: set-heavy-track02.mp3 at 60% Vol.
ROCKER: zig-zag-3 at 45% Intensity
NOTIF: Notifying in 155s...

Hardware at a glance

Arduino microcontroller

Motion Sensor

Cradle Rocker Servo

Android Smartphone with camera and WiFi

"Baby Awake" alert

Parent's phone

What the Arduino is responsible for

What the smartphone is responsible for

How it's meant to work

Baby wakes up

Motion sensor detects movement

Camera activates

AI processes baby's face

Baby is asleep

Baby is awake

Start cradle rocker

Play lullaby

Stop lullaby and rocking

Check if crying threshold exceeded

Threshold NOT exceeded

Threshold exceeded

Notify parents

AI checks if baby still crying

Baby fell asleep

Baby still crying

Adjust lullaby

Parent responds to baby and resets system

Dataset used

The City Infant Faces Database is comprised of:
- 54 photographs of negative ("distressed") infant faces
- 40 photographs of neutral infant faces.
- 60 photographs of positive ("happy") infant faces

Training stats

- Transfer learning applied on pretrained MobileNetV2 model.
- Exported as quantised tflite model for efficient use in mobile devices

- Dataset used is too small.
- Only three classes used for ease of training.
- Model not reliable enough for real life use.
- Larger, more diverse dataset needed to improve detection accuracy for each mood/class.
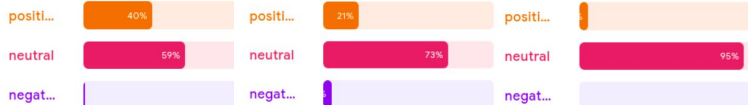- Real life system must be able to detect many more nuanced infant moods.
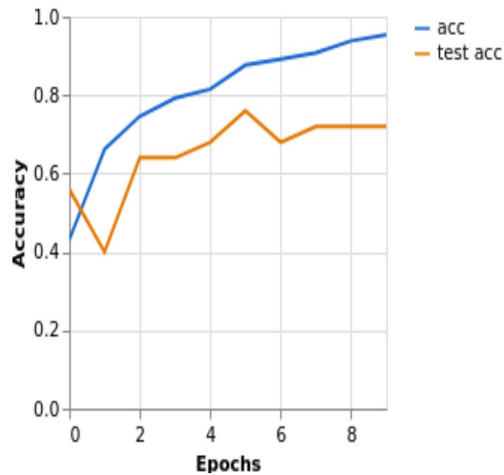
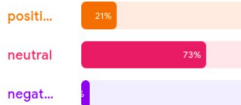| CLASS	ACCURACY	# SAMPLES
positive	0.89	9
neutral	0.71	7
negative	0.56	9
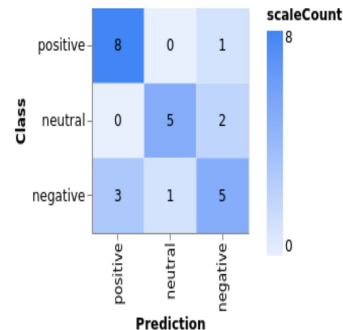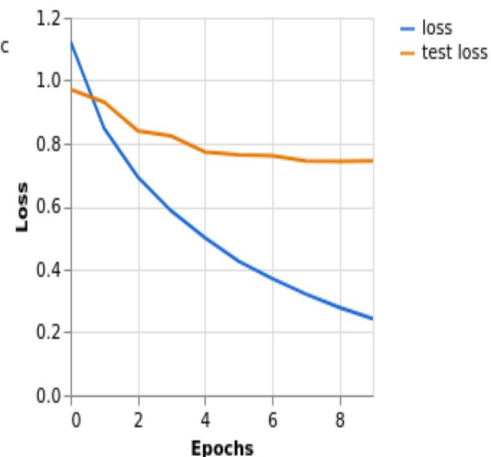
AI in action
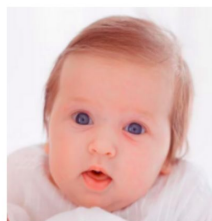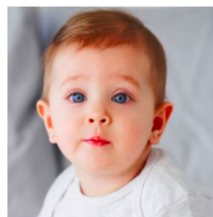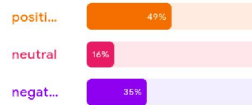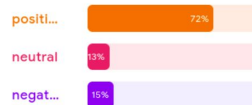

Trained and tested using Google Teachable Machine
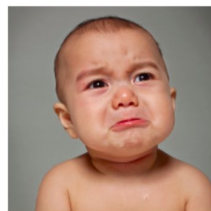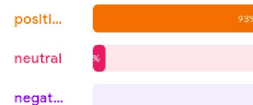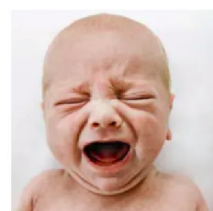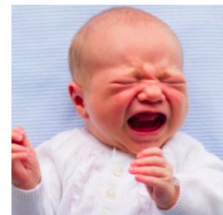
How the baby is detected to be awake

- PIR sensor is polled over a period of time
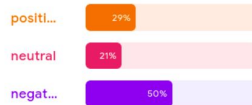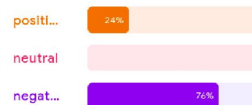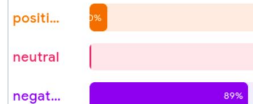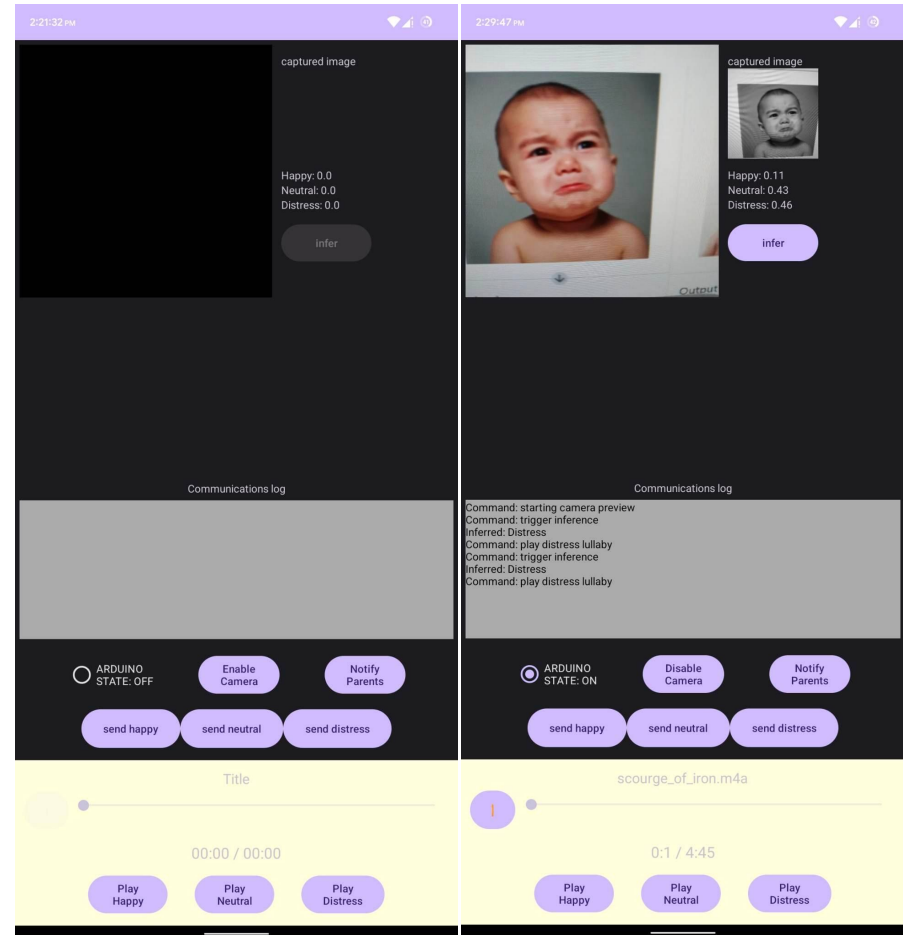- Use of non-blocking timers.
- If baby is constantly moving for a set threshold period, camera is activated to check state.
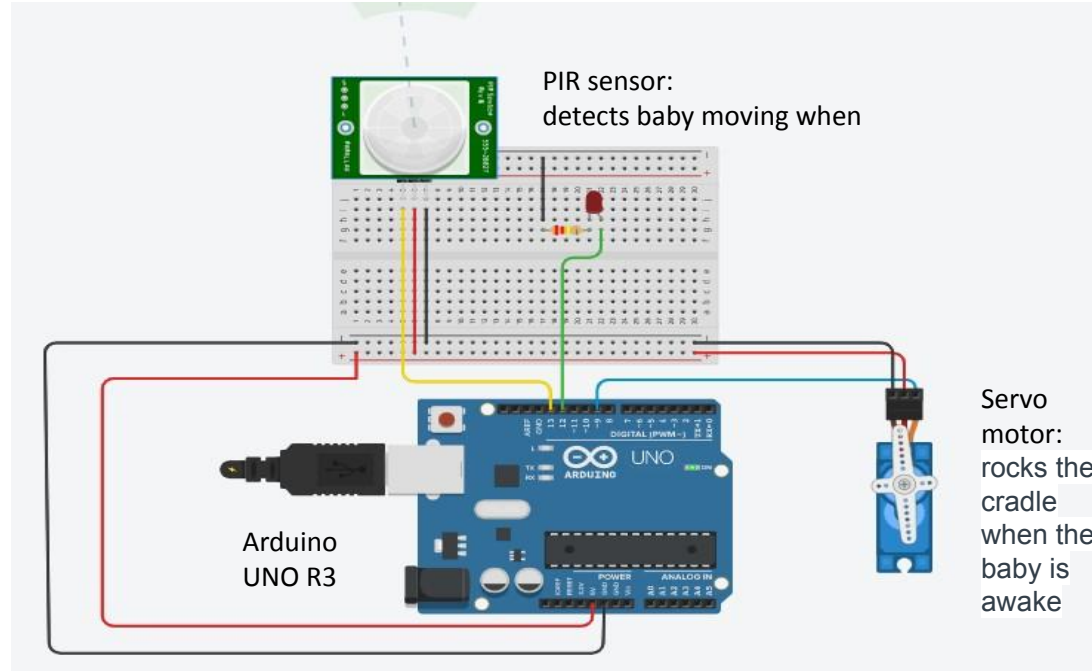- Cooldown period is observed if baby momentarily stops moving - ensures briefs periods of rest are ignored

```cpp
bool checkBabyAwake() {

    unsigned long const SENSOR_COOLDOWN_THRESHOLD_MILLIS = 2000;
    unsigned long const AWAKE_DECISION_THRESHOLD_MILLIS  = 8000;

    int sensor_reading = digitalRead(SENSOR_PIN); digitalWrite( LED_PIN, sensor_reading );

    if ( isSensingMovement ) {

        if ( sensor_reading == HIGH ) {
            isSensorInCooldown = false;
            if ( currentTimeMillis - movementStartMillis > AWAKE_DECISION_THRESHOLD_MILLIS ) {
                return true;
            }
        } else {
            if ( isSensorInCooldown ) {
                unsigned long timeElapsedCoolingDown = currentTimeMillis - sensorCooldownStartMillis;
                if ( timeElapsedCoolingDown > SENSOR_COOLDOWN_THRESHOLD_MILLIS ) {
                    isSensingMovement = false;
                }
            } else {
                sensorCooldownStartMillis = millis();
                isSensorInCooldown = true;
            }
        }

    } else {

        if ( sensor_reading == HIGH ) {
            isSensingMovement = true;
            movementStartMillis = millis();
        }

    }
    return false;
}
```

Android Application UI

- Prototype app UI intended for testing various features.
- Major elements:
  - Camera preview
  - Captured image preview
  - Inference results
  - Arduino communications log
  - Music Player
- Various buttons to trigger functionalities manually for testing purposes.
- Plays music from a stored playlist according to instructions from arduino
- Notify functionality not implemented yet - requires building a web service from scratch capable of serving notifications, and streaming video feed.

Hardware prototype in Tinkercad

PIR sensor:
detects baby moving when

Servo motor:
rocks the cradle when the baby is awake

Arduino UNO R3

Cradle Oscillation Demo

Cradle Demo

TODO

- ~~Find dataset of baby images~~

- ~~Train MobileNetV2 model using transfer learning.~~

- ~~Develop Android app.~~

- ~~Build prototype of smart cradle.~~

- ~~Write microcontroller code.~~

- ~~Interface Arduino-Android via USB.~~

- Develop parent notification system.

- TEST TEST TEST

  - Issues with AI inference - likely due to incorrect preprocessing of camera feed

For more information, please refer to:
https://treedweller98.github.io/CradleSite/