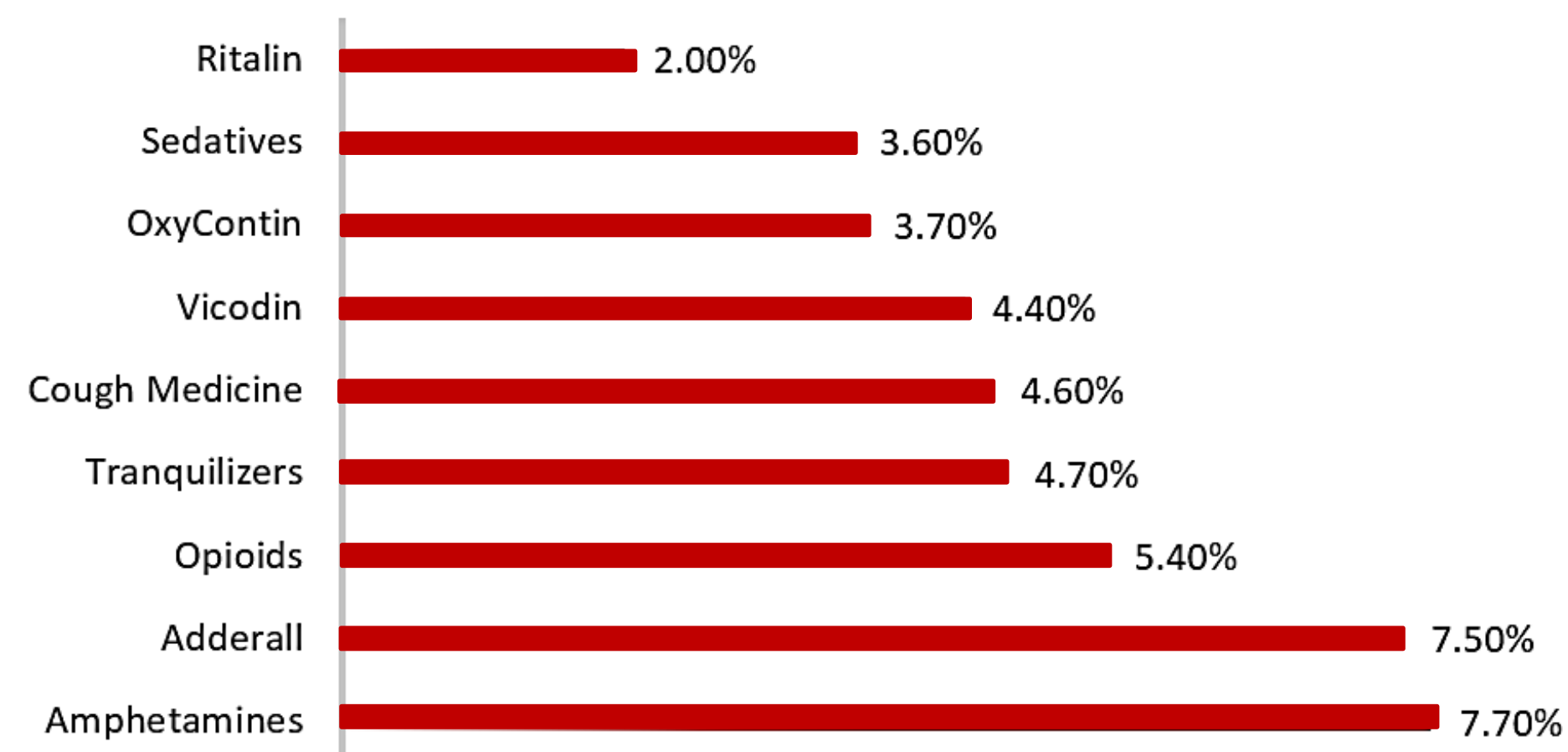


Hero: Automated Detection System for Prescription Drug Overdose

INTRODUCTION

- Every hour, an American teen dies by prescription stimulant overdose, adding up to over 10,000 deaths in 2019.
- Prescription stimulants, drugs commonly prescribed to teens to treat attention-deficit-hyperactivity disorder (ADHD) or increase alertness, were misused by over 15% (addition of Adderall and Amphetamine rate) of high school and college students in 2018.

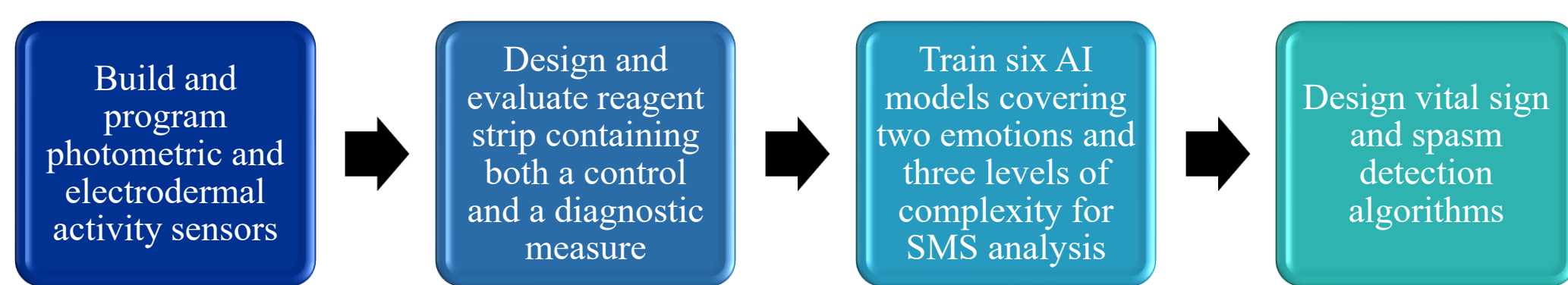
PERCENTAGE OF HIGH SCHOOL SENIORS WHO ABUSED PRESCRIPTION DRUGS IN 2018



Data from National Institute on Drug Abuse (NIDA)

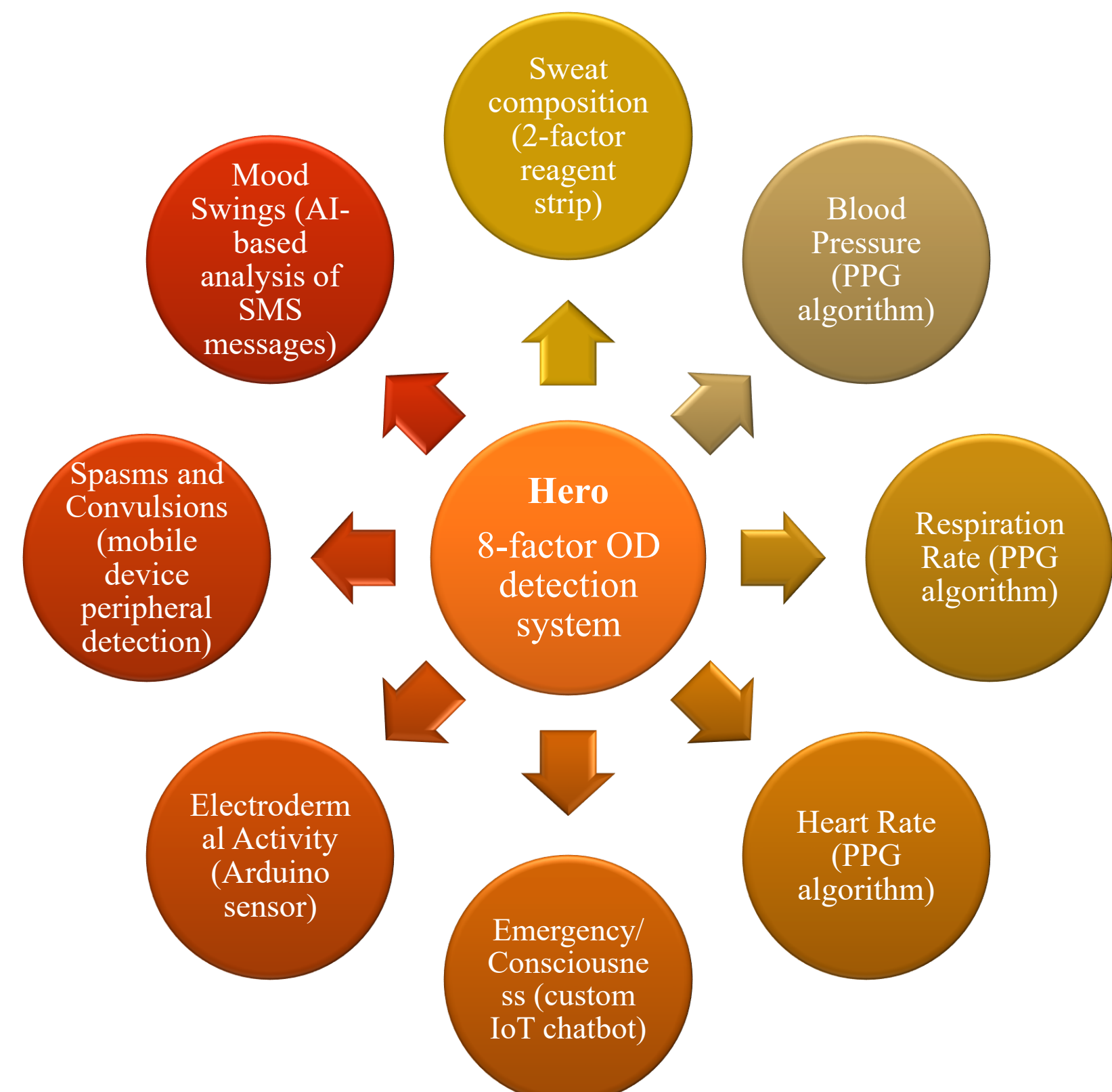
- As shown in the graph above, generic amphetamines and Adderall (the most common brand name for prescription stimulants) were misused by 12th graders in the US more commonly than opioids and other sedatives.

METHODS



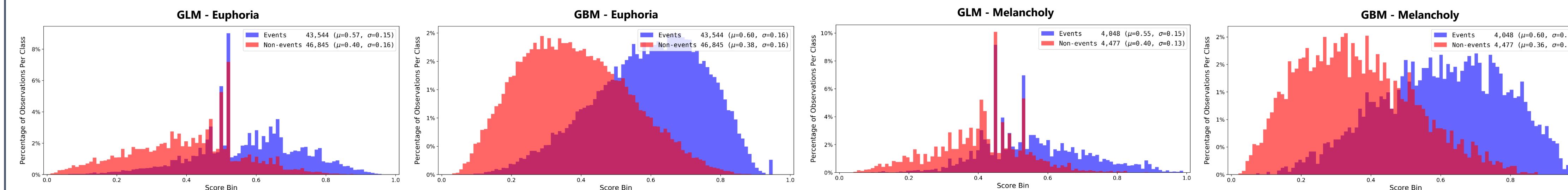
- Step 1 Materials: Arduino Uno board, bread board, photometric sensor, TFT display, WiFi module, jumper wires, Arduino Nano board, EDA sensor electrodes
- Step 2 Materials (Gold Nanoparticle Test – Diagnostic Measure, pH Test – Control Measure): Hydrogen Tetrachloroaurate (III) Trihydrate (HAuCl₄•3H₂O), Trisodium Citrate Dihydrate (C₆H₅Na₃O₇•2H₂O), Benzoic Acid (C₆H₅COOH), Hydrochloric Acid (HCl), Sodium Hydroxide (NaOH), Sodium Chloride (NaCl), Anthocyanin and litmus indicator

PROPOSED SOLUTION



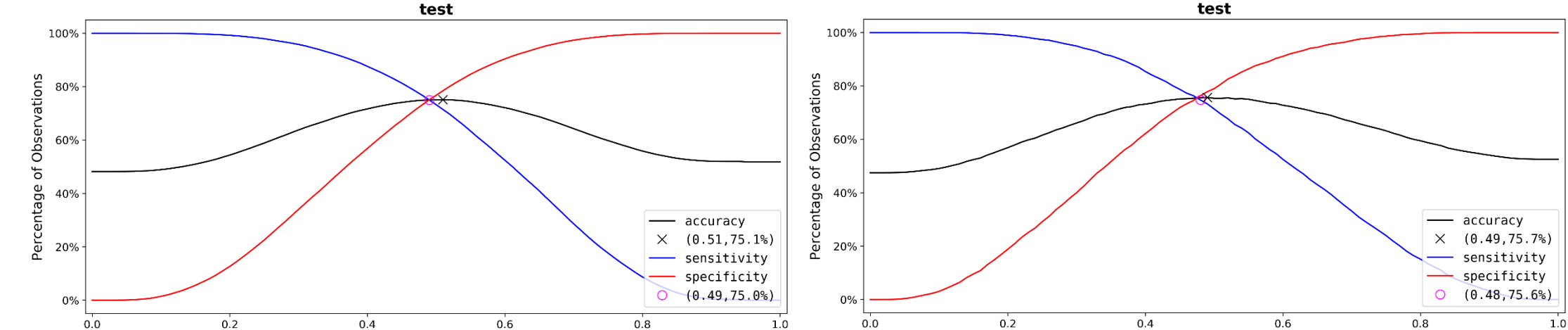
- The proposed solution is a prototype system named Hero, a framework which incorporates eight factors to detect an overdose in real-time.
- Hero takes advantage of a user's existing phone, laptop, device accessories, and/or voice-activated assistant devices such as a Google Mini to create a comprehensive overdose detection system.

RESULTS – MOOD SWINGS



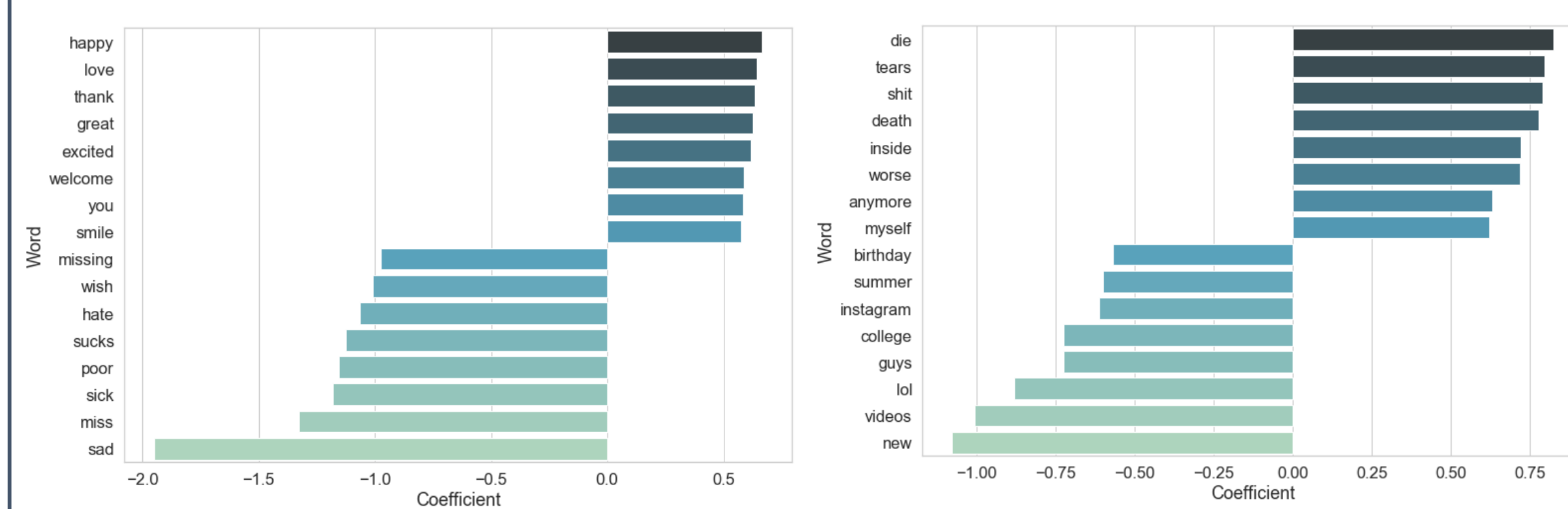
Determining Optimal Threshold (GBM)

- The figures below show accuracy, sensitivity, and specificity as the score threshold between case and control changes for GBM.
- For euphoria (left), in testing, 0.51 was the score threshold with maximum accuracy, and 0.49 was the score threshold where all three measures are optimal.
- For melancholy (right), in testing, 0.49 was the score threshold with maximum accuracy, and 0.48 was the score threshold where all three measures are optimal.



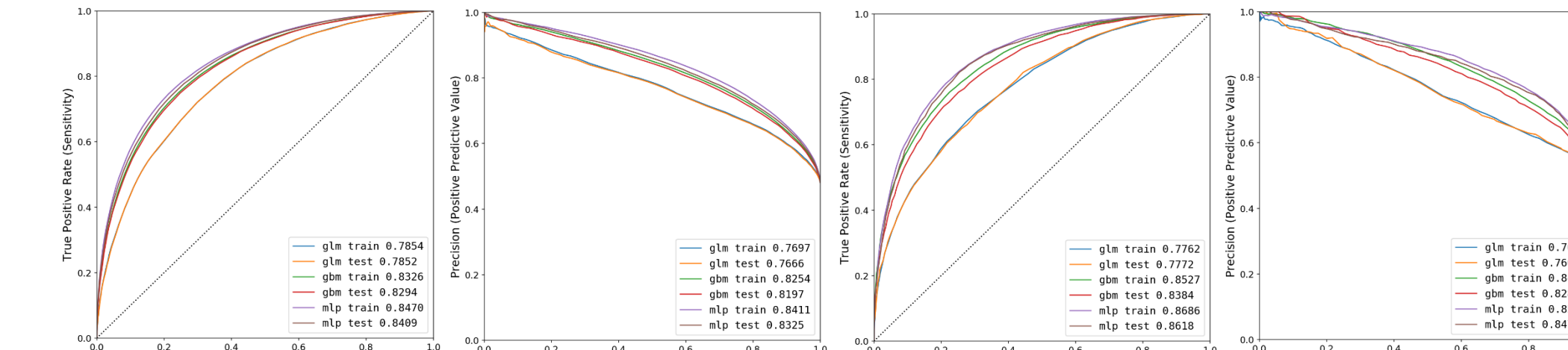
Important Features (GLM)

- The figures below show the features (words) that were determined to be the most indicative of euphoria (left) or melancholy (right) by the GLM model
- The word most predictive of euphoria was "happy" with a coefficient of 0.665, and the most protective word was "sad" with a coefficient of -1.948
- The word most predictive of melancholy was "die" with a coefficient of 0.824 and the most protective word was "new" with a coefficient of -1.079



Accuracy

- The Receiver Operating Characteristic curve plots the False Positive Rate (1 – specificity) against the True Positive Rate (sensitivity).
- For euphoria, GLM testing had an AUC of 0.7852, GBM testing had an AUC of 0.8294, and MLP testing had an AUC of 0.8409 (a 5.57% increase).
- For melancholy, GLM testing had an AUC of 0.7762, GBM testing had an AUC of 0.8384, and MLP testing had an AUC of 0.8618 (a 8.56% increase).
- For euphoria, the average precision increased by 6.59% between GLM and MLP, and for melancholy, the percent increase was 8.10%.



Network Architecture

- The architecture of the feed-forward network is shown above. The MLP contains an input layer, two hidden layers, and an output layer.
- The Rectified Linear Unit (ReLU) activation function is used for the hidden layers, and the Sigmoid activation function is used for the output layer

Timeline Extrapolation

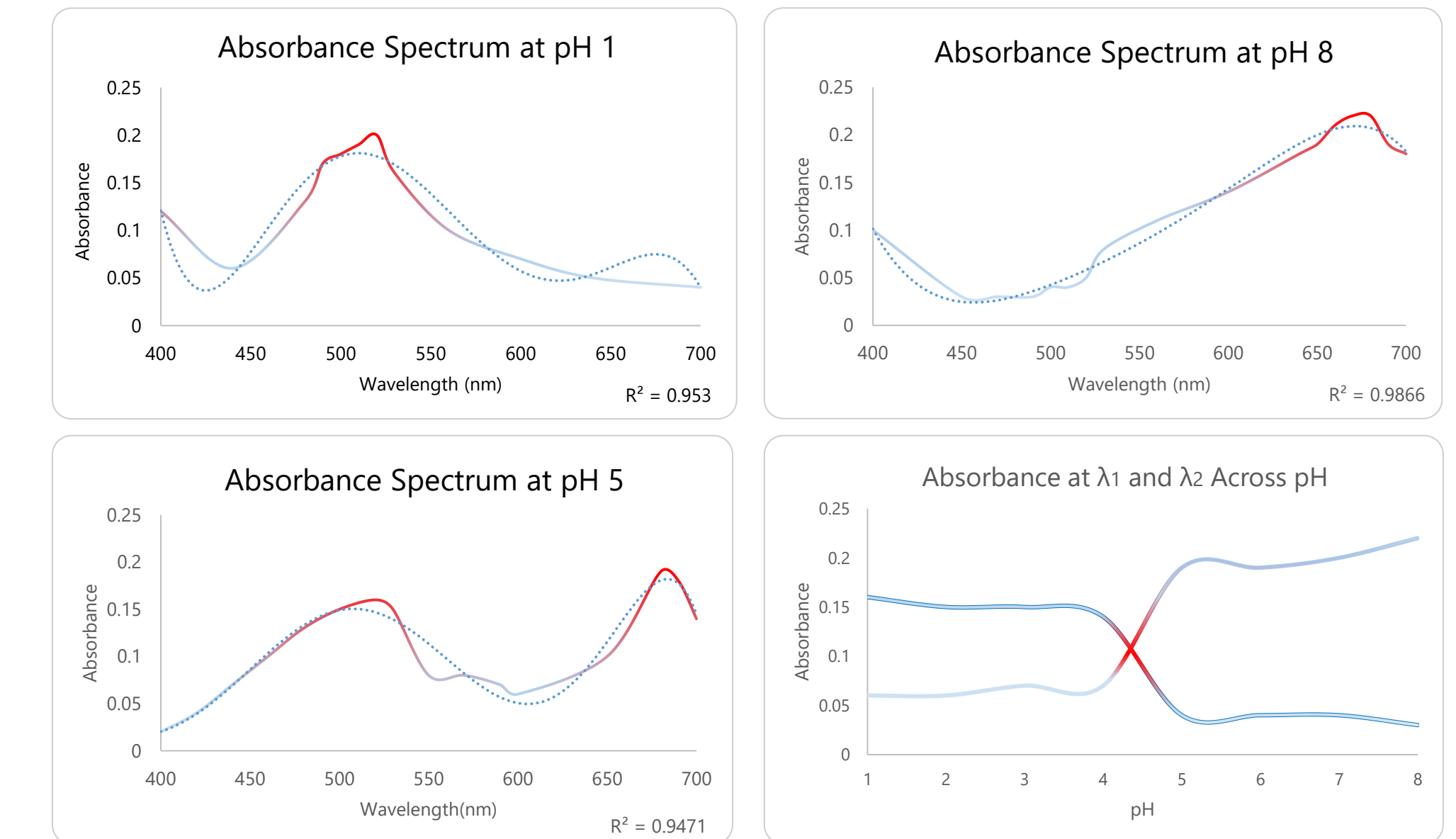
- Each SMS message is scored using both the euphoria and melancholy models, and the higher score is plotted chronologically
- Differences are computed to detect a mood swing. Scores from the sadness model are shown as negative values.



RESULTS – SWEAT COMPOSITION

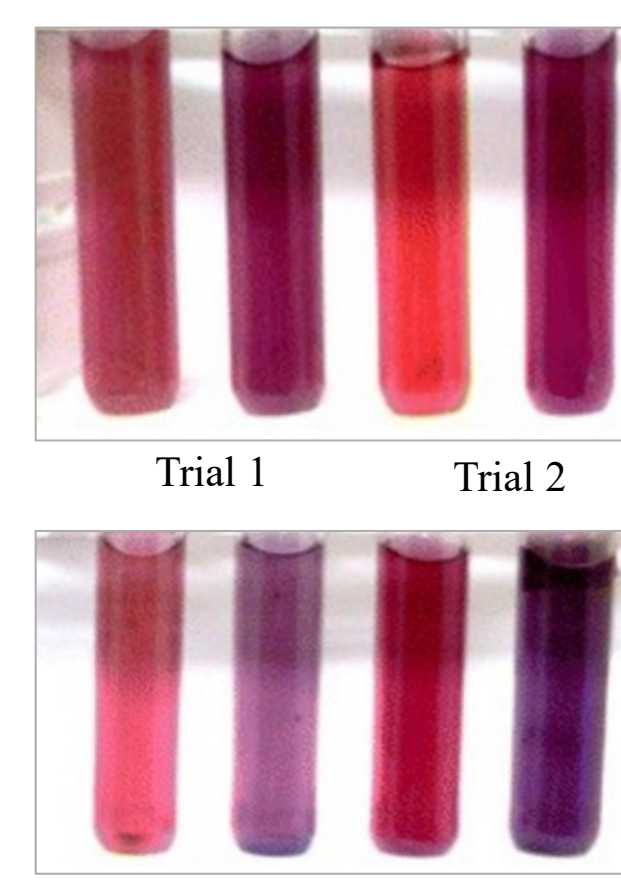
Control Measure – pH Test

- The absorbance spectra for the final anthocyanin-litmus indicator solutions at pH 1, 5, and 8 are shown to the right.
- Two lambda max values were selected based on the spectra, one in which acidic solutions absorbed optimally (520 nm) and one in which basic solutions absorbed optimally (680 nm).
- Absorbance across the pH spectrum at these wavelengths was then measured (shown below) to find the pH range and pKa value.
- pKa value was found to be ~4.35, and based on the fact that the anthocyanin indicator will change color at a pH of approximately 4.35, when 25 microliters of sweat are added, the pH of the strip must surpass pH 4.5 to exhibit a significant color change.
- The volume of the original pH 3 solution to be placed on the strip was calculated as 0.815 microliters. This value was approximated down to 0.750 microliters during strip testing to account for slightly acidic sweat.



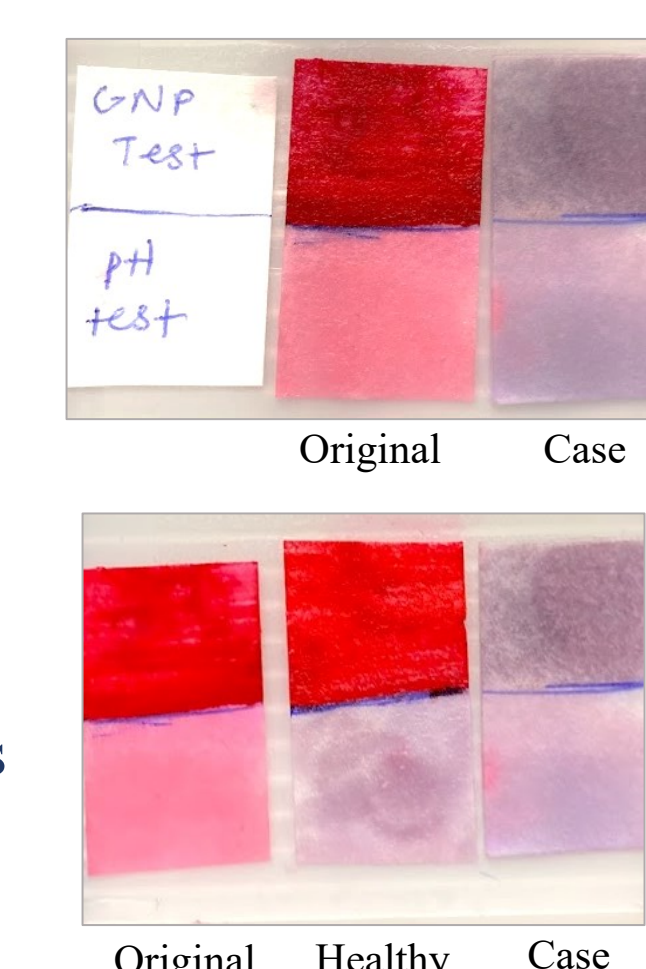
Diagnostic Measure – GNP Test

- The images to the right show the color change from four trials of citrate synthesis.
- With each trial, the amount of simulated sweat was incremented, and the observed color change became more apparent (25, 50, 75, and 100 microliters).
- Case sweat was simulated by combining distilled water, NaCl, and benzoic acid (at concentrations described in prior literature).
- A visible color change occurred almost instantaneously and persisted for at least 20 minutes.



Overall Strip Evaluation

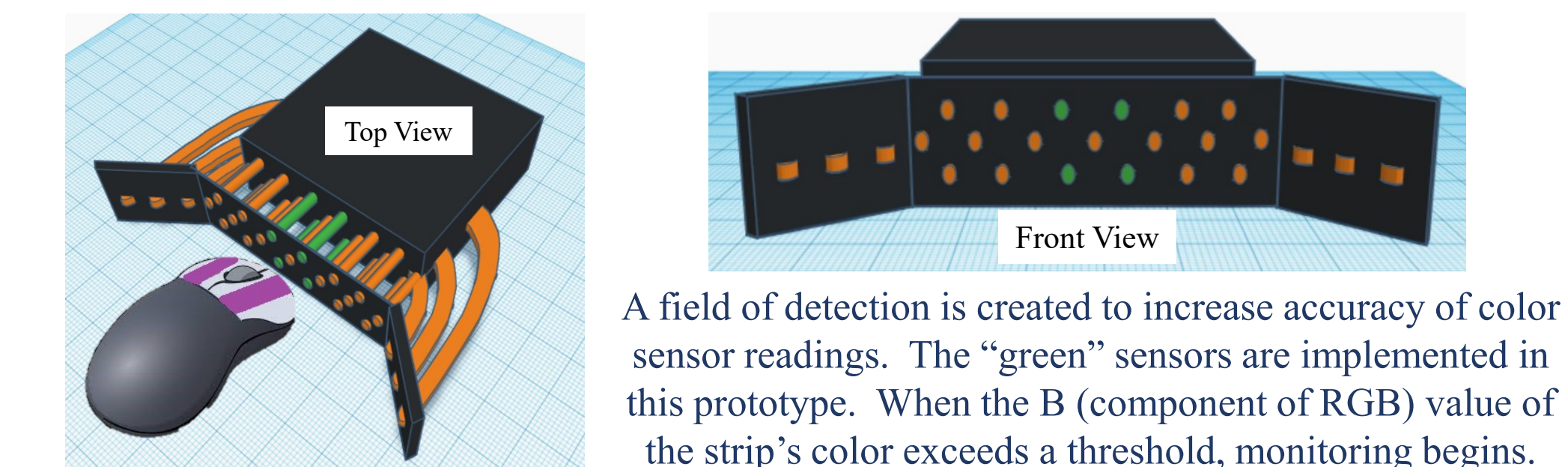
- The figures to the right display the final color changes on the strip.
- The bottom half of the strip is the control measure and changes color for all sweat (no matter the composition) and the top half is the diagnostic test.
- The control test indicates that the strip has come in contact with adequate sweat. This would prevent false positives.



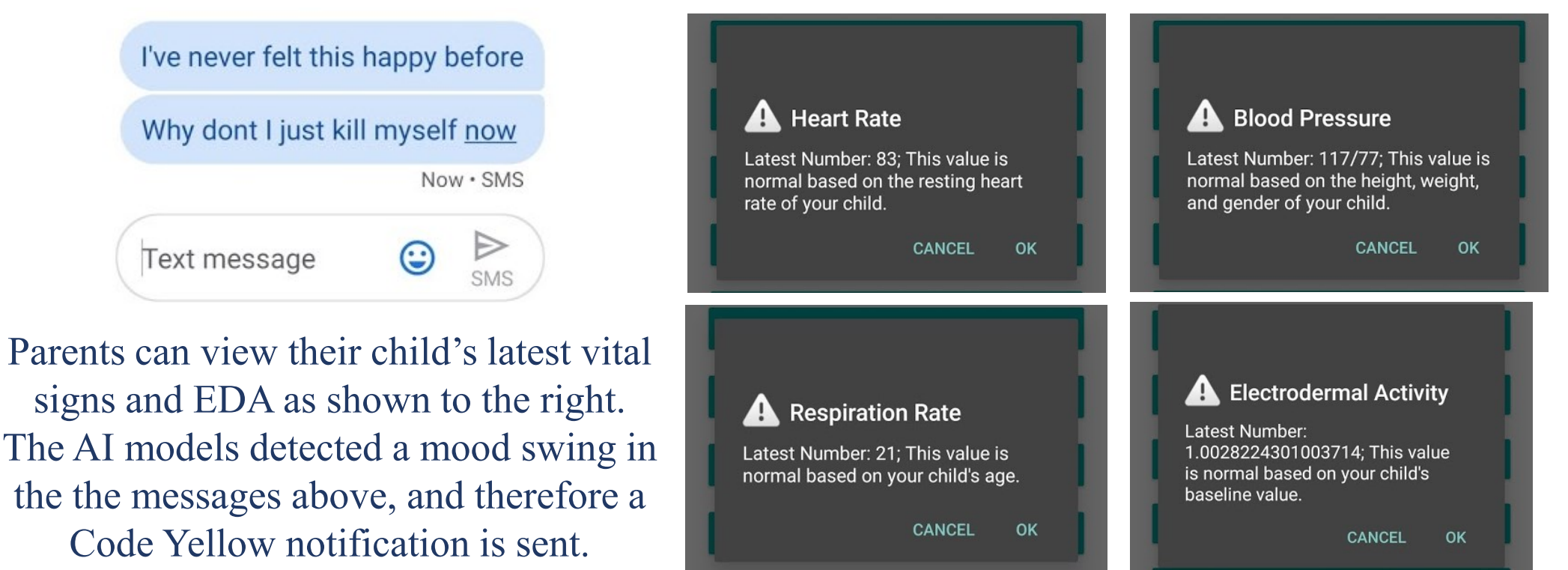
SYSTEM DESIGN

Overdose Episode

Hero begins monitoring when the factor that the parent has set to "trigger" in their notification preferences exceeds a specified threshold. The recommended triggering factor is sweat composition. When the reagent strip changes color, the drug has hit the user's bloodstream, and this is the time when physical and emotional symptoms will begin.



A field of detection is created to increase accuracy of color sensor readings. The "green" sensors are implemented in this prototype. When the B (component of RGB) value of the strip's color exceeds a threshold, monitoring begins.



Parents can view their child's latest vital signs and EDA as shown to the right. The AI models detected a mood swing in the messages above, and therefore a Code Yellow notification is sent.

- Hero Alert - Code Yellow**: Sample Child's total score is greater than the recom. Sent when composite score (based on notification preferences) increases 0.5
- Hero Alert - Code Red**: Sample Child is likely to have experienced a spasm. Sent when spasm detected or respiration rate <7
- Hero Alert - Emergency**: Sample Child needs immediate help. Sent when child asks for help through Google Mini

RESULTS – SPASM DETECTION

Trial Number	Time to Notification (seconds)
1	4.6
2	4.3
3	5.2
4	4.7
5	5.0
6	4.2
7	4.3
8	4.7
9	4.8
10	4.4

- Shakes were simulated and time to notification was measured by the Java program.
- The mean time in seconds taken to send a notification was 4.62 seconds with a standard deviation of 0.31.
- In less than 5 seconds, this algorithm can detect a spasm or convulsion, save this information to the database, and send a notification to a parent.

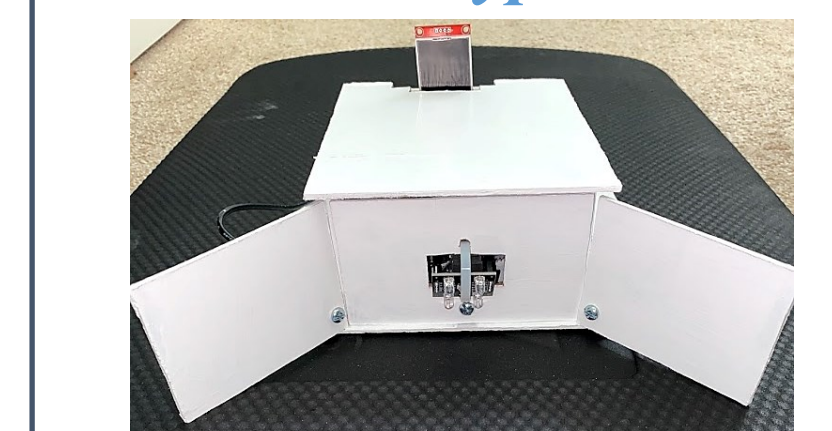
RESULTS – PROTOTYPE TESTING

Prototype 1



Prototype	RGB Value Average % Error	Time Taken to Begin Monitoring (seconds)
1	6.4%	4.5
1	6.5%	4.8
1	6.1%	4.4
1	5.8%	4.5
2	2.2%	2.9
2	2.4%	2.5
2	2.3%	2.6
2	2.4%	2.7

Prototype 2



The initial prototype was tested for % error of sensing (average 6.2%) and time taken to begin monitoring (average 4.55 seconds). A second prototype was created to increase the sensing angle. The time improved by 41.2% (average 2.675 seconds) and % error decreased by 62.5% (average 2.325%).

CONCLUSIONS

- The vital sign algorithm performs with an accuracy of 97.86%, which is much higher than previous PPG-based algorithms.
- The spasm detection algorithm performs in under 5 seconds.
- The final mood swing detection model had an accuracy of over 85%. 0.50 was selected as the threshold for emotion determination.
- The reagent strip exhibits a color change which can be detected by a sensor prototype with 97.675% accuracy
- All eight factors are implemented into the Hero mobile application, and are based on devices that a teen would likely already use in their life