Senior Design Team 301:
Safe-X

Team Introductions

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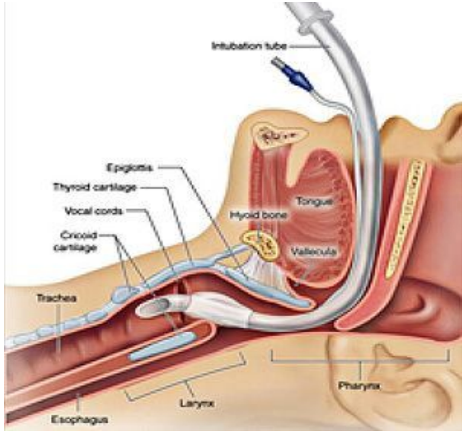
Project Background

Intubation - A procedure in which an **endotracheal tube** is inserted through patient’s mouth into their trachea to:

- Support breathing in patients who cannot do so on their own
- Remove blockages in airways
- Prevent fluid from getting into a patient’s lungs



Intubation is required for many health crises, including: heart attack, stroke, respiratory diseases (pneumonia, covid-19), collapsed lungs, and more

Project Background

Extubation - A procedure in which the endotracheal tube is removed from the patient

Extubation Failure - The need to re-intubate a patient within hours or days

- Planned extubations fail in 10-20% of patients with a mortality rate of 25-50%
- Other consequences include increased length of hospital stay and higher ICU costs

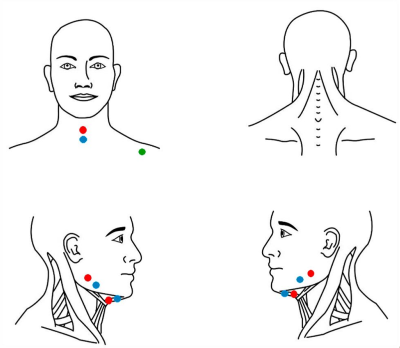
TABLE 1. RATES OF PLANNED EXTUBATION FAILURE AND MORTALITY

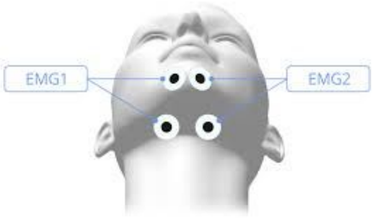
Study (Reference)	Number of Extubations	Rate of Extubation Failure [% (n)]	ICU Mortality in Reintubated Patients [% (n)]	ICU Mortality in Nonreintubated Patients (%)
Esteban *et al.*, 1997 (1)	397	19 (74)	27 (20)	3
Esteban *et al.*, 1999 (2)	453	13 (61)	33 (20)	5
Epstein *et al.*, 1997 (4)	287	14 (40)	43 (17)	12
Vallverdu *et al.*, 1998 (3)	148	15.5 (23)	35 (8)	5.6
Thille *et al.*, 2011 (6)	168	15 (26)	50 (13)	5
Frutos-Vivar *et al.*, 2011 (14)	1,152	16 (180)	28 (50)	7
Funk *et al.*, 2009 (38)	257	10 (26)	Not available	Not available
Tonnelier *et al.*, 2011 (39)	115	10 (12)	Not available	Not available
Sellares *et al.*, 2011 (34)	181	20 (36)	Not available	Not available
Peñuelas *et al.*, 2011 (40)	2,714	10 (278)	26 (72)	5

Project Scope

Project Description:

Safe-X is a prototype that processes EMG signals in order to perform data classification to inform a doctor as to when a patient can be safely extubated





Assumptions:

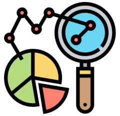
EMG signals scan various neck and throat muscles to determine patient stability

The project's core subjects include Signal Processing and Machine Learning

Project Scope

Key Goals:

Read and Interpret EMG Signals



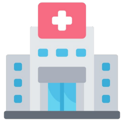
Highly Accurate Classification Model

Create an operable prototype as a major deliverable by the end of the academic year

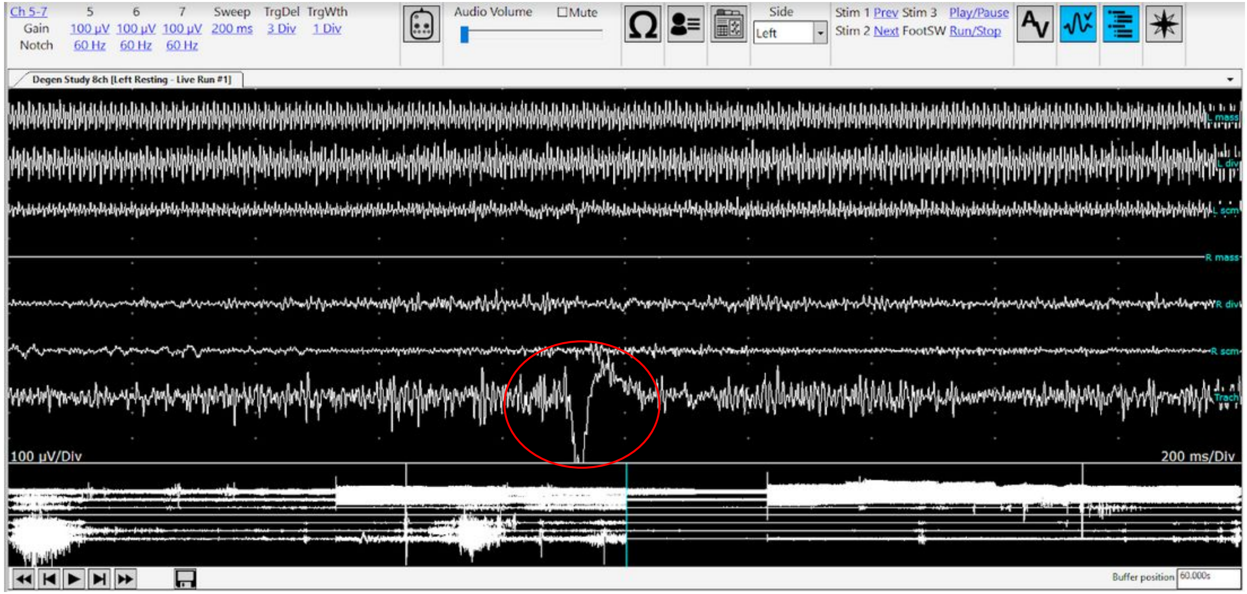
Markets:

Primary Market: Hospitals

Secondary Markets: At home patients, Hospice Centers, Field Doctors



Project Scope - EMG Example



Left Masseter
Left Digastric
Left Sternocleidomadtoid

Right Masseter
Right Digastric
Right Sternocleidomadtoid

Trachea

Customer Needs

- Needs were primarily derived from meetings with Dr. Freeman
- No product on the market that analyzes risk factors for extubation
- Failed extubation causes stress on other parts of the body and is sometimes fatal

Customer Needs

- Portable → Easily transported between rooms
- Display → LED or LCD to indicate when it is safe to extubate
- Interface with EMG → Signals from surface EMGs
- Classification Model → Machine learning algorithm determines if a patient can be safely extubated
- User Friendly → Easy for nurses and doctors to use

Project Plan

Major steps that must be taken to complete the project:

1. Collaborate with Mayo Clinic to gather large amounts of data with normals and a benchmark for abnormals
2. Obtain budgetary information for electronic components needed for device
3. Determine microcontroller necessary for project by measuring capabilities of running signal processing and machine learning software
4. Determine EMG sensor necessary for ensuring portability and accuracy of device (wireless, # of electrodes)

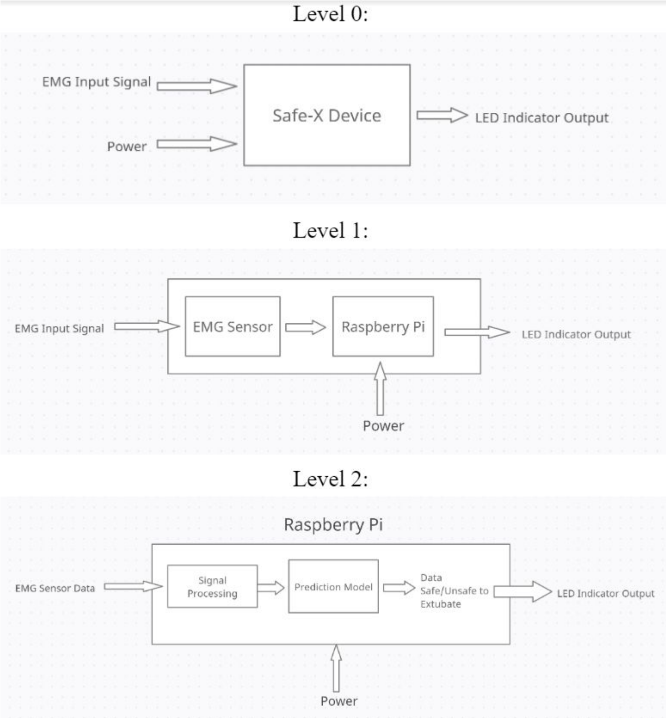
Project Plan

5. Develop software prototypes for signal processing algorithm and machine learning model
6. Order electronic components and begin testing
7. Implement signal processing algorithm and classification model on the device
8. Test device using various sets of abnormal EMG data for classification

Functional Decomposition

Major Functions

- EMG Interface
  - Read EMG Signals
- Signal Processing
  - Convert signals from analog to digital
  - Record patterns in data
- Machine Learning
  - Classification algorithm to classify if patient is safe to extubate



Other Considerations

- Benchmarking Abnormals
  - Reading a passage
  - Moving tongue
  - Swallowing
  - Coughing
  - Smiling/Frowning
  - Flexing neck muscles

- Other Risk Factors
  - Age
  - Previous health issues (heart attack, stroke, etc)
  - Length of time on mechanical ventilation

Presentation Recap

- High extubation failure rate
- Portable device needed for accurate predictions
- Device will read neck muscle activity
- Muscle signals will be read, processed, and fed into a machine learning algorithm to determine if it is safe to extubate
- Device will use training data gathered by Mayo Clinic to improve classification accuracy and efficiency

Questions?