Safe-X
Targets

Introduction

The primary functions (Fx.x) of the device, from the *Functional Decomposition*, include an EMG sensor, a signal processing algorithm, and a machine learning prediction model. Each of these functions have various objective measurements that can be used to measure performance (targets). In addition to function targets, the device requires a few top-level targets to objectively determine performance and how well the device matches customer needs. These device level functions (Dx.x) include the portability of the device, the battery life of the device, and the brightness of the indicator display (currently an LED).

Derived Methods

The methods for measuring function/device performance differ for each target. However, the primary functions are mostly mathematical calculations, while the device level functions are more general measurements. The following are descriptions for each method of validating individual targets:

EMG Sensor

Gain - The gain of the EMG sensor must be similar to that of Mayo Clinic's current EMG machines, as too much or little of an amplitude change would deliver signals different than those tested on. Gain is typically measured through the sensor, but mathematical operations can be performed to measure it through the processing algorithm.

Bandwidth - The bandwidth of the EMG sensor must cover the same range as Mayo Clinic's current EMG machines, allowing Safe-X's sensor to capture a full spectrum of signals. Bandwidth is typically measured through the sensor, but mathematical operations can be performed to measure it through the processing algorithm.

Peak-to-Peak Voltage - The peak-to-peak voltage capabilities on the EMG Sensor must be able to capture the same signal peaks as Mayo Clinic's EMG machine. Peak-to-Peak voltage is typically measured through the sensor, but mathematical operations can be performed to measure it through the processing algorithm.

Signal Processing Algorithm

Execution Time - The signal processing algorithm must have a reasonable execution time so that digital signal (output) data loaded into the prediction model is up-to-date. The execution time of the algorithm can be gathered in the development environment the algorithm is running on.

RAM Usage - The RAM usage of the signal processing algorithm must not exceed the RAM on the microcontroller to prevent crashes. Ram usage can be measured via the microcontroller's internal measurement tools.

Machine Learning Prediction Model

R-Squared Value - One of the most common measurements of accuracy in machine learning is an R-Squared Value (r^2), which will directly show how accurate the model is. This value can be measured through various Python libraries for machine learning.

Confusion Matrix - A confusion matrix will report the percentages of false positives and false negatives, better informing the Safe-X team as to where prediction failures occur. This matrix can be developed through various Python libraries for machine learning.

F1-Score - Another common measurement of accuracy in machine learning which can be used to reinforce the accuracy measurement obtained from the R-Squared Value. This value can be measured through various Python libraries for machine learning.

Execution Time - Similar to the signal processing algorithm, the execution time of the prediction model is important to ensure that indication for proper extubation can be given in a reasonable period of time. The execution time of the algorithm can be gathered in the development environment the algorithm is running on.

Portability

Volume - The dimensions of the device are the most objective measurement of portability and the general size was derived by obtaining the dimensions of other handheld devices (ex. Alexa Echo Show 5). The dimensions of the device can be gathered by manual measurement or by reviewing documentation on ordered parts.

Battery Life

Time - The time that the device can remain powered without being plugged in, which should be long enough for it to observe at least one patient. The battery life time can be measured by recording the time from full charge until the device dies.

Display

Brightness - The brightness of the LED display indicator is important to ensure that the user can adequately see the light turn on and receive indication for proper extubation. A blinking of the light is also being considered for further indication. An LCD display with current patient vital signs and an obvious indicator for proper extubation is also being considered. The brightness can be measured by determining the voltage pushed to the LED indicator.

Summary

The individual targets discussed above cover both the primary functions of the device along with device-level properties that should be met according to customer needs. Though data was able to be gathered for most of the functions, more metrics may be needed to report a more

complete measurement of performance. Specifically, marginal and ideal values (see below table) for different measurements are still yet to be determined for some metrics, as without an ordered device and information from Mayo Clinic, exact values cannot be determined. Therefore, though most of the methods of measurements will not change throughout the process of the developing the Safe-X device, our measurements of success and their exact values may.

Metric No.	Metric Name	Need	Metric	Importance	Units	Marginal Value
F1.1	EMG Sensor	3, 5	Gain	High	V	100 uV
F1.2	EMG Sensor	3, 5	Bandwidth	Moderate	Hz	-
F1.3	EMG Sensor	3, 5	Peak-to-Peak Voltage	Moderate	V	-
F2.1	Signal Processing Algorithm	3	Execution Time	High	Time (s)	-
F2.2	Signal Processing Algorithm	3	RAM Usage	Moderate	MegaBytes (MB)	-
F3.1	Machine Learning Algorithm	4	R-Squared Value	High	r^2 (Percentage)	0.75
F3.2	Machine Learning Algorithm	4	Confusion Matrix	High	Percentages	-
F3.3	Machine Learning Algorithm	4	F1-Score	Moderate	Percentage	0.8
F3.4	Machine Learning Algorithm	4	Execution Time	Moderate	Time (s)	-
D1	Portability	1, 5	Volume	High	$(l * h * w)in^3$	15 * 9 * 6
D2.1	Display	2	Resolution	Moderate	Pixels	1920x1080
D2.2	Display	2	Refresh Rate	Moderate	Hz	60

Fig. 1 - Summary Table - Targets Appendix