Intelligent Bionic Hand

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1.00	8 Nov,2017	Initial discussion
2.00	17 Nov,2017	2nd Draft
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Document Approval:

The following document has been accepted and approved by the following:

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List of Contents

List of Figures

List of Tables

1 INTRODUCTION

1.1. PURPOSE

The purpose of this document is to define the requirements (both functional and non-functional) for the Intelligent Bionic hand. Software Requirements Specification (SRS) allows to verify the customer or stakeholder that all his/her requirements are observed and will be implemented correctly by developer. The final product of the team will meet the requirements of this document. This document will highlight all the necessary information needed to start developing the Bionic hand.

This document plans to provide guiding principle on the basis of which the success of the system would be measured and how these ideas and thoughts will be made, viably. The prerequisites will be exhibited utilizing textual information to clarify ideas, distinctive sorts of diagrams to represent complicated connections, and tables to relate relevant information. The target group of this document is all the stakeholders. This incorporates, yet is not restricted to, software developers, hardware designers, project managers and clients.

1.2. PRODUCT SCOPE

The primary objective of this work is to develop an anthropomorphic and dexterous hand for the treatment of amputees.

Firstly, we looked at the existing systems. These systems made use of image processing i.e. they used camera mounted on top of the hand , camera recognize and analyze the object and then the software devises the plan to deal with that object.

Other systems are invasive which means brain is connected to the bionic hand using electrodes. Most of the time amputee use just a dummy hand because above mention systems are expensive, heavy weight and noisy.

In an effort to provide low cost and light weight prosthetic hand we will use minimum servo motors and lightweight 3-D printed hand and this artificial hand will be interfaced with forearm to perform three type of motions, which respectively are:

- Grasp
- Victory sign
- Pinch

Table 1: Terms used in this document and their description

Name	Description
SBC	A single-board computer is a complete computer built on a single circuit board, with microprocessor, memory, input/output and other features required of a functional computer.
Deep learning	Deep learning is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms.
Servo Motors	A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.
CNN	In machine learning, a convolutional neural network (CNN, or ConvNet) is a class of deep, feed-forward artificial neural networks that has successfully been applied to analyzing visual imagery.

2 OVERVIEW

2.1 THE OVERALL DESCRIPTION

Our project consist of four parts. They are:

- 3D printed hand
- Single board Processor
- Electric Circuit
- Sensors

The sensors are attached to the forearm of amputee, which collects neural data. The data is passed to processor module.
In the processor module, the Sensory data is classified to appropriate motion (grasp, victory sign and pinch.) deep learning algorithms using then electric circuit is triggered for corresponding motion.

2.2 PRODUCT PERSPECTIVE

The product is supposed to be an open source, under the GNU General Public License. This project is a standalone system that provides functionality describe in requirements section. The main purpose of this project is to provide a functional hand, to the amputee, at low cost. It will dependent upon different kinds of hardware i.e. Sensors, SBC, Servo Motors and Electric circuit. The mechanism of the project has been shown using the diagram below:

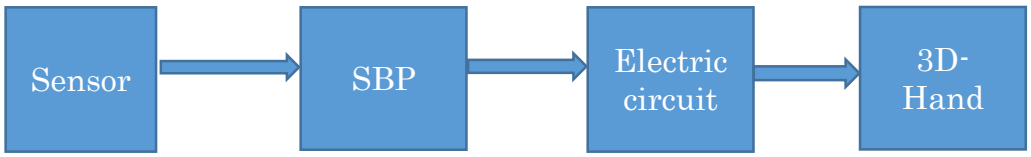


Figure 1

2.2. PRODUCT FUNCTIONS

The project will perform the following major functions:

- Record neural signals at forearm.
- Convert the neural signals to digital signals.
- Classification these signal using Deep Learning algorithms [1].
- Trigger electronic circuitry for corresponding hand motion.

2.3. USER CHARACTERISTICS

Amputees (hand) will be the users of this system. The users will not require to have a high level of technical knowledge.

2.3. CONSTRAINTS

The proposed project must take care of the following constraints:

- Getting 100% accurate neural data might not be possible.
- Many actions can't be performed.
- We're not interfacing the brain bionic hand with brain, the data may be noisy.
- The 3D design of hand may affect different hand motion.

2.4. ASSUMPTIONS AND DEPENDENCIES

We assume that once we train Convolutional neural network with Training Sample, it will work for every amputee without training the CNN for particular person.
Our work is highly dependent on accuracy with which Sensors collect the data at forearm of amputee.

3 USER REQUIREMENT

3.1 External Interface Requirements

3.1.1 User Interfaces

- There is minimal user interaction with system.
- The system is plug and play.
- User just have to power the system and send neural signals to forearm from his brain.

3.1.2 Hardware Interfaces

- Sensor at forearm would be used to collect neural data.
- Raspberry Pi/Arduino is a low power mini CPU. When configured, it can be used to receive data from the sensors, classify it and then trigger electric circuit for appropriate motion.[2]

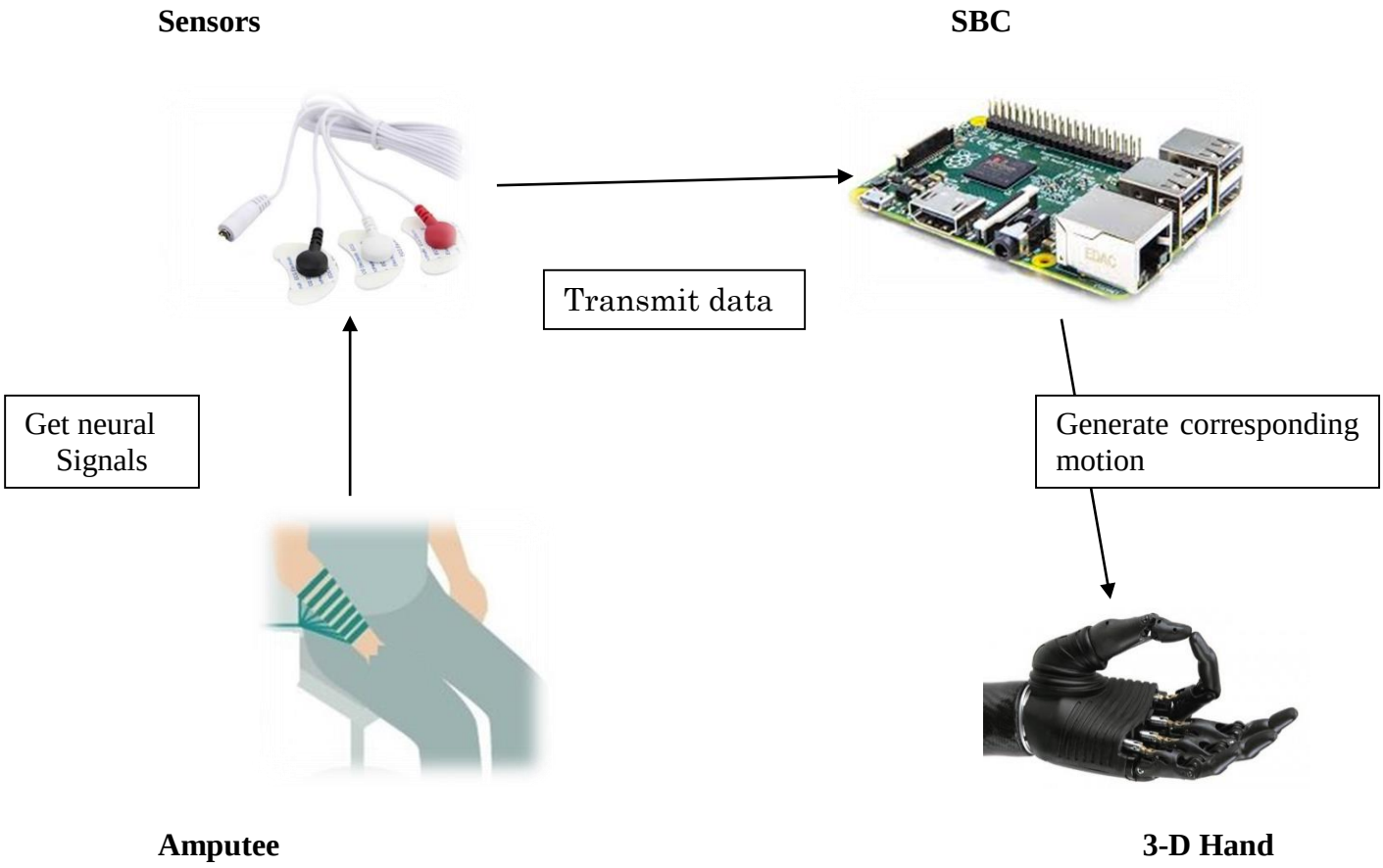


Figure 2

3.1.3 Software Interfaces

- Raspberry Pi/Arduino would be configured with its built in interface. We can then use its port to connect it with the sensors.

3.1.4 Communication Interfaces

- Sensors will require communication with Raspberry Pi/Arduino in order to record data, in real time. This will be done through serial jump wires.

4 Functional Requirements

List of all the functional requirements:

4.1 Functional Requirements with Traceability information

Requirement ID	REQ01		**Requirement Type**		Functional Requirement		**Use Case #**				
Status	***New***		***Agreed-to***	-	***Baseline***	-	***Rejected***	-			
Parent Requirement #											
Description	The system should record neural data at forearm and transmit it to SBC.										
Rationale	To do Classify the data and get useful information										
Source					**Source Document**	-					
Acceptance/Fit Criteria	The system should successfully and accurately record and transmit the data.										
Dependencies											
Priority	***Essential***		***Conditional***	-	***Optional***	-					
Change History											

Table 4.1

Requirement ID	REQ02		**Requirement Type**	Functional Requirement		**Use Case #**		
Status	***New***		***Agreed-to***	-	***Baselined***	-	***Rejected***	-
Parent Requirement #								
Description	The system should Classify the data using deep learning algorithms and find appropriate motion against given data.							
Rationale	To trigger electric circuit for corresponding motion.							
Source					**Source Document**	-		
Acceptance/Fit Criteria	The type of motion should match user expected motion.							
Dependencies								
Priority	***Essential***		***Conditional***	-	***Optional***	-		
Change History								

Table 4.2

Requirement ID	REQ03		**Requirement Type**	Functional Requirement		**Use Case #**		
Status	***New***		***Agreed-to***	-	***Baseline***	-	***Rejected***	-
Parent Requirement #								
Description	The electric circuit should move fingers of 3D printed hand according to type of hand motion.							
Rationale	To show hand motion.							
Source					**Source Document**	-		
Acceptance/Fit Criteria	The type of motion generated by electric circuit should match type of motion SBC predicted.							
Dependencies								
Priority	***Essential***		***Conditional***	-	***Optional***	-		
Change History								

Table 4.3

5 Nonfunctional Requirements & Software System Attributes

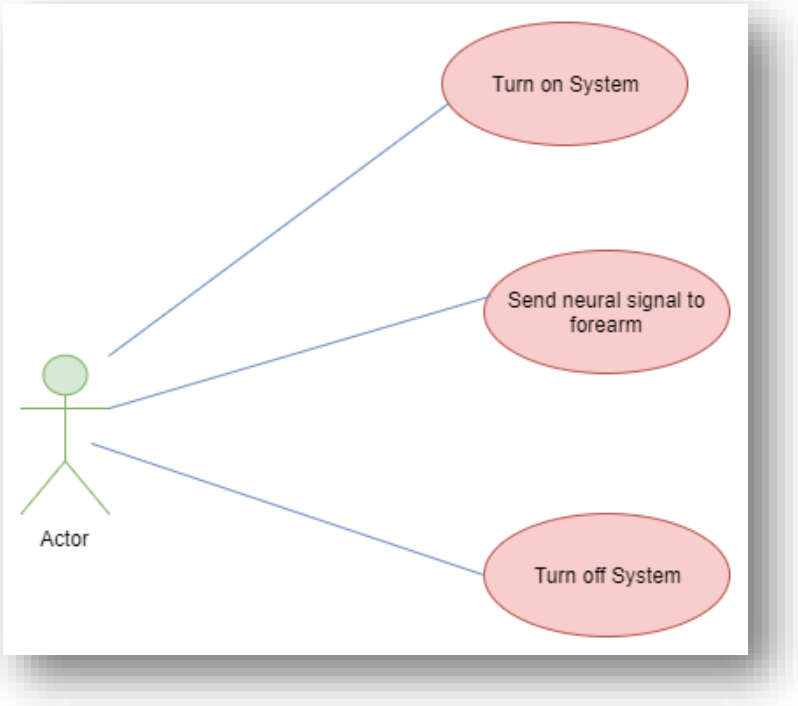
- Availability: The system should be up and running when user want to.
- Extensibility: The System can be extended to more hand motion.
- Recoverability: In case of a system failure, system shall resume operations within seven minutes.
- The maximum weight of the prosthetic hand should not exceed 5 lbs.

5.1 Performance Requirements

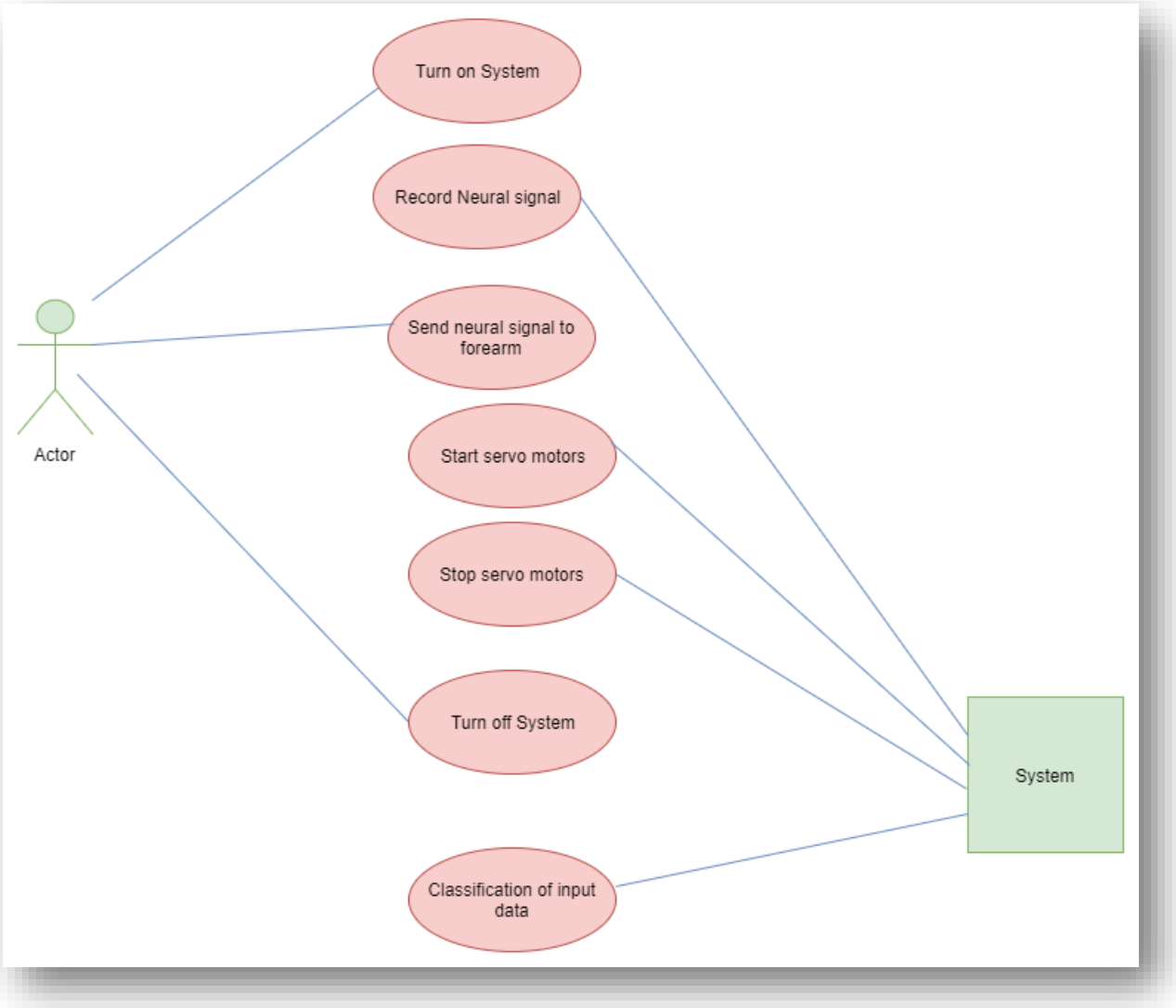
- The Single board computer should have high speed, so that it processes the sensory data as fast as possible.
- Sensors should have high accuracy in recoding signal at forearm.
- The availability of the system should be 100%.
- The cylindrical grasp shall pick up 500-700 ml of liquid, as this is standard soft drink mass for a 21 ounce cup.
- The pinch grasp shall pick up 2-30 grams of fries at a time, as it is standard for one French fry to weigh 2 grams.

6 USE CASES: (Diagrams)

Use case for User:



Use case for whole system:



7 References

[1] https://www.frontiersin.org/articles/10.3389/fnbot.2016.00009/full#h8
[2] https://www.nature.com/articles/nature17435