SAN JOSÉ STATE UNIVERSITY

# Report on SignComm Project

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## Abstract

The main objective of this paper is to design a convenient, handy and cost effective model which can be used to convert the sign language to text and reduce the gap among speech impaired people. The main problem that the speech impaired people need to tackle while interacting with normal people can be overcome by constructing an effective communication system which would allow them to communicate without an interpreter. A motion capture device Leap Motion which has inbuilt cameras and infrared LEDs is used to develop our project.

# Background

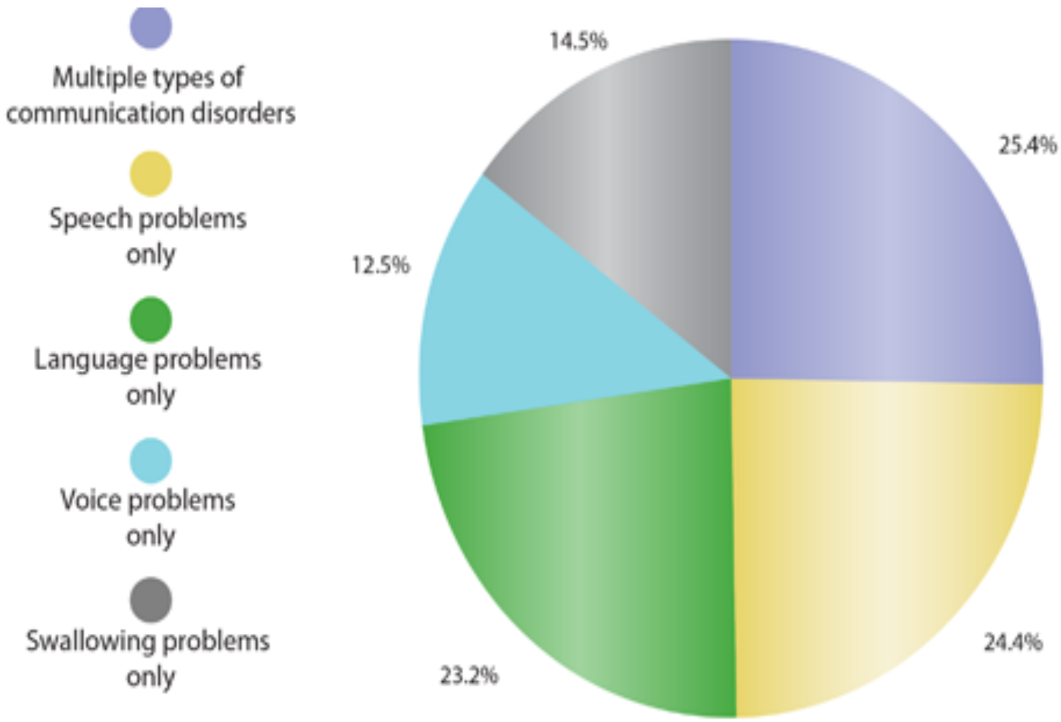
According to the recent studies made by Worlds Health Organization (WHO) in 2015, 7.5% of the world's population is suffering with hearing disabilities. They communicate among themselves using sign language (by making gestures) which involves combination of the hand movements, facial expressions, and body language.

Sign language is the sixth most spoken language in the world. But the people suffering from hearing disabilities cannot communicate with the rest of the world. This is because not many people are familiar with the sign language. With rapidly growing technology, it is high time to come up with a solution which reduces the gap among the people.

Natural language processing (NLP), is the process to convert the natural language (sign language) to the human understandable manner (speech and text) with minimal effort by the user by just doing the signs in front a machine. The machine will interpret the signs.

There are few technologies which are currently available for performing NLP such as wearable gloves with embedded sensors and accelerometer to track the hand movements of the user but these are not available widely and not very cost effective, and these wearables are not advisable for some health reasons such as the sensors which are connected to them produces waves which are harmful to the user in long run.

## Statistics of Communication Disorders



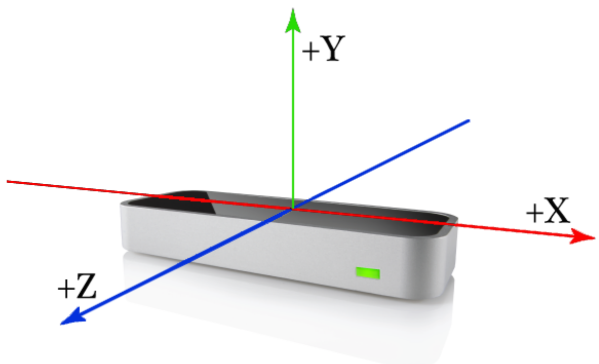
## Proposed System/Infrastructure

The proposed systems understands the human gestures and converts them to meaningful texts using Leap Motion Controller. The controller is a small peripheral device which can be connected to the laptop or desktop and provides the User Interface for the user. The field of the UI/UX is excelling and providing a friendly user interface for human and machine interactions in all the fields. Leap Motion offers a an advantage by providing this friendly User Interface for capturing gestures and interpreting.

This new idea of integrating the UI with gestures is enormous, and the leap motion also provides another great advantage that it does not need any direct physical contact by the user which may sometimes prove useful for certain set of people and make their lives easier.

## Leap Motion Controller

Leap Motion Controller is a sensor device that can create and recognize gestures made by hand and finger motions. It's a compact, portable USB peripheral device. There are two infrared cameras that are of high precision and three LEDs to detect and track hand information like motion and position. It operates approximately at the rate of 200 frames/second.




The sensors  and cameras which are present in the leap motion can capture hands and tools. Leap Motion tracks the hand as a general object, allowing for actions like pinching, crossing fingers, moving one hand over another and hand-to-hand interactions like brushing and tapping fingers on one another.

The API combines the use of Neural Networks to track moving data efficiently.  The data captured by the leap motion are saved in tn the form of frames. Leap analyses the overall motion which occurred since an earlier frame and synthesizes representative translation, rotation, and scale factors .

Leap motion provides the leap motion SDK which supports various languages such as C++, C#, Java, Python, Unity, JavaScript and the SDK provides an inbuilt APIs which as methods which can be used to train the machine.

# Commercial Aspects of Leap motion

Researchers all over the world are developing Gesture Recognition System to interpret human gestures that has enormous applications. It allows us to communicate with the machines without any mechanical device. Following are some applications where Gesture Recognition can be very useful.

Cars - Gestures can be used to interact with the Center Display of Head-up displays of the car. They can be used for climate control, turn volume up or down, hop between radio station and songs.

Medical surgery - Gestures can be used by the Surgeons at the medical centers to zoom in, swipe or rotate the reports and other details related to the surgery on screen without any contamination as it is touch-free.

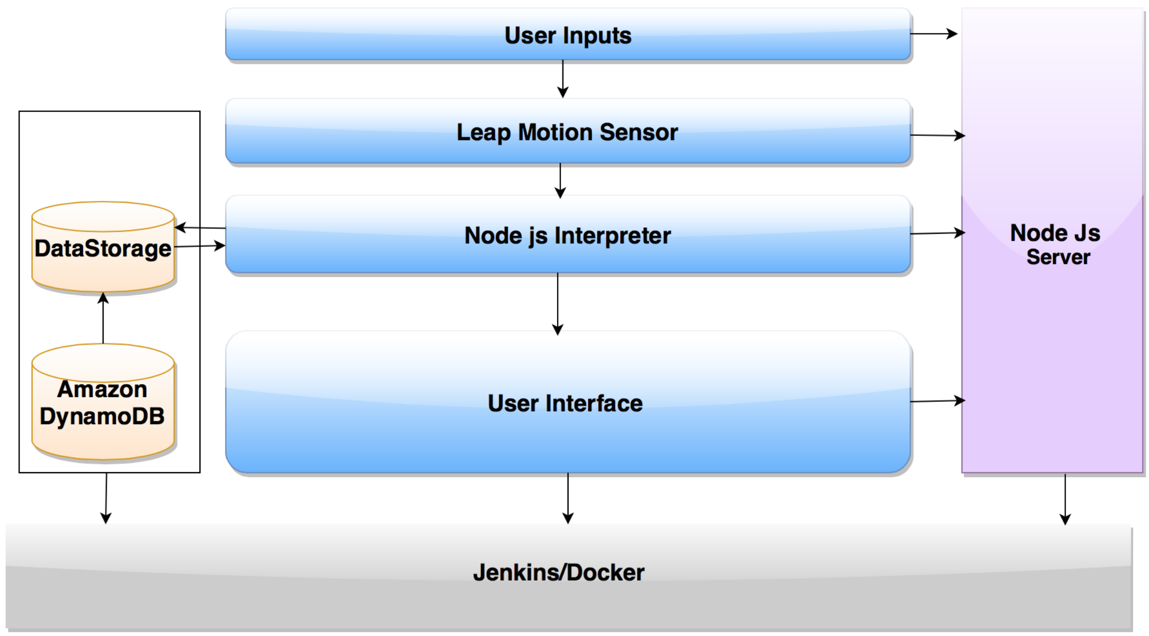
Smart TV - They can be used to build smart TV's without remote controller. Gestures can be used to switch channels, play and pause videos, change volume, surf web, play games etc.

Automated Homes - By connecting the gesture recognition system to Wi-Fi, one can turn out lights, turn on/off television, music system, or change room's temperature. This would be most useful for old people.

Music system - A smart musical system software's are available where you can only make gestures to play sounds.

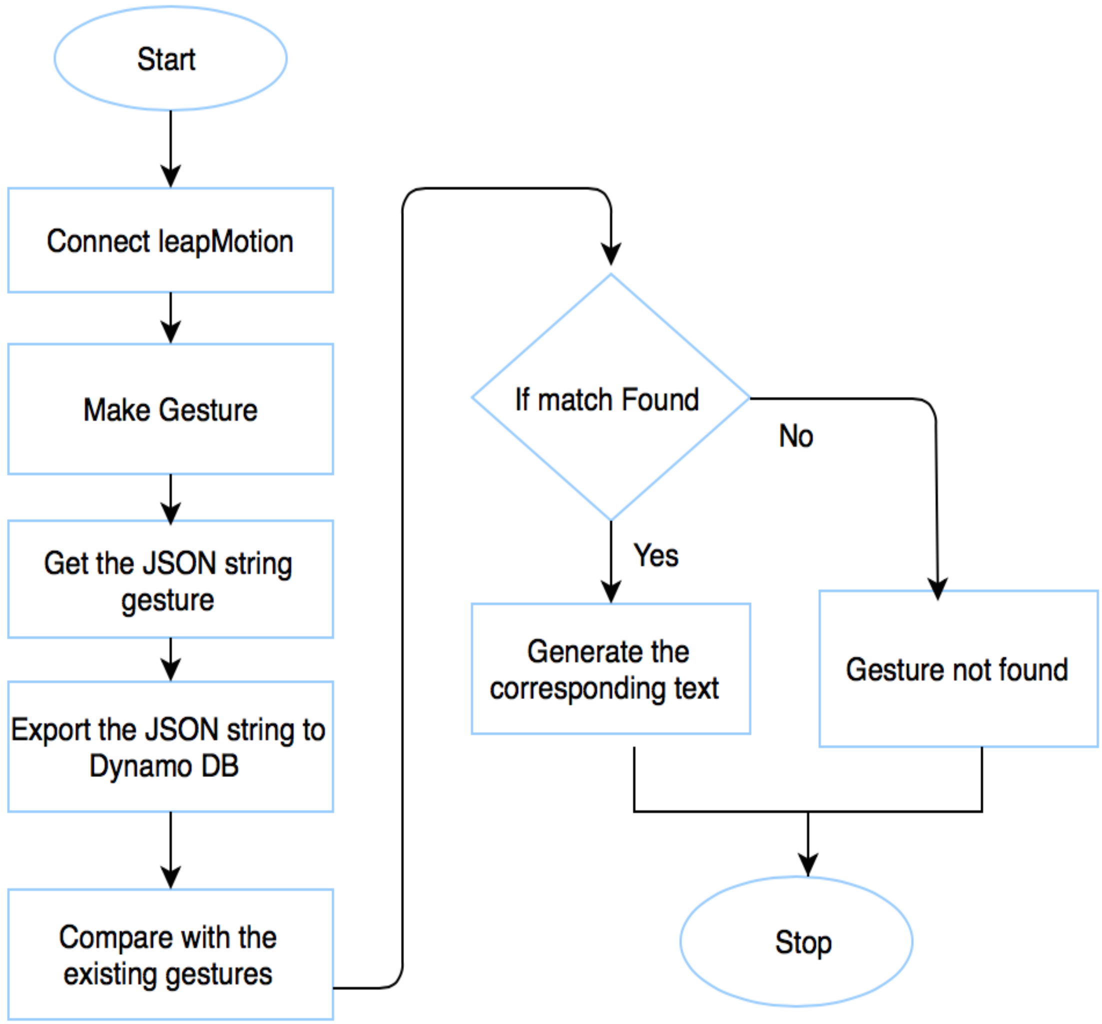
Sign language recognition - This can be very useful for speech impaired people or deaf people who use sign language for their communication.

# Architecture of SignComm




The web application incorporates the platform to support the overall flow of the data and client interactive elements. The home screen is the main page for  the web application. The visible user Interface components and non visible logic of the application is developed using JavaScript and the Leap Motion Sensor is used to for capturing gestures and the logic for the application implementation, data work flow is developed in JavaScript using Leap SDKs. The output from the Leap Motion is captured in the JSON format is interpreted by the signs which are stored in the database are fetched from Amazon Dynamo DB by using Node.js. The resulted text will be displayed to the user. The entire code is hosted in the Jenkins to ensure the version control.

Figure below shows the major services offered and the overall data flow between the users.




Overall Data Flow :

1. Connect the Leap Motion device to the laptop or PC
2. Make the Gesture in front of the Leap Motion
3. Collect the output which is given by the leap motion trainer in the form of frame Ids and convert into the JSON string
4. Export the JSON string to the database (DynamodB)
5. Compare the string with the existing data in the database
6. If there is match display the result in the dashboard

# Implementation Details

Leap Motion Trainer :

The leap motion training is done in JavaScript programming in the host laptop. Leap captures the gestures made by the user and using the Leap Motion APIs, the gestures are converted into JSON payloads.

Code Snippet 1 from the SignComm Controller:

```
// Setup Leap loop with frame callback function
var controllerOptions = {enableGestures: true};

// to use HMD mode:
// controllerOptions.optimizeHMD = true;

var readGesture = true;
Leap.loop(controllerOptions, function(frame) {
  leapAnimate(frame);
  if (paused) {
    return; // Skip this update
  }
  if (frame.gestures.length && readGesture) {
   readGesture = false;
  // Display Frame object data
  var frameOutput = document.getElementById("frameData");
```

Code Snippet 2 from the SignComm Controller :

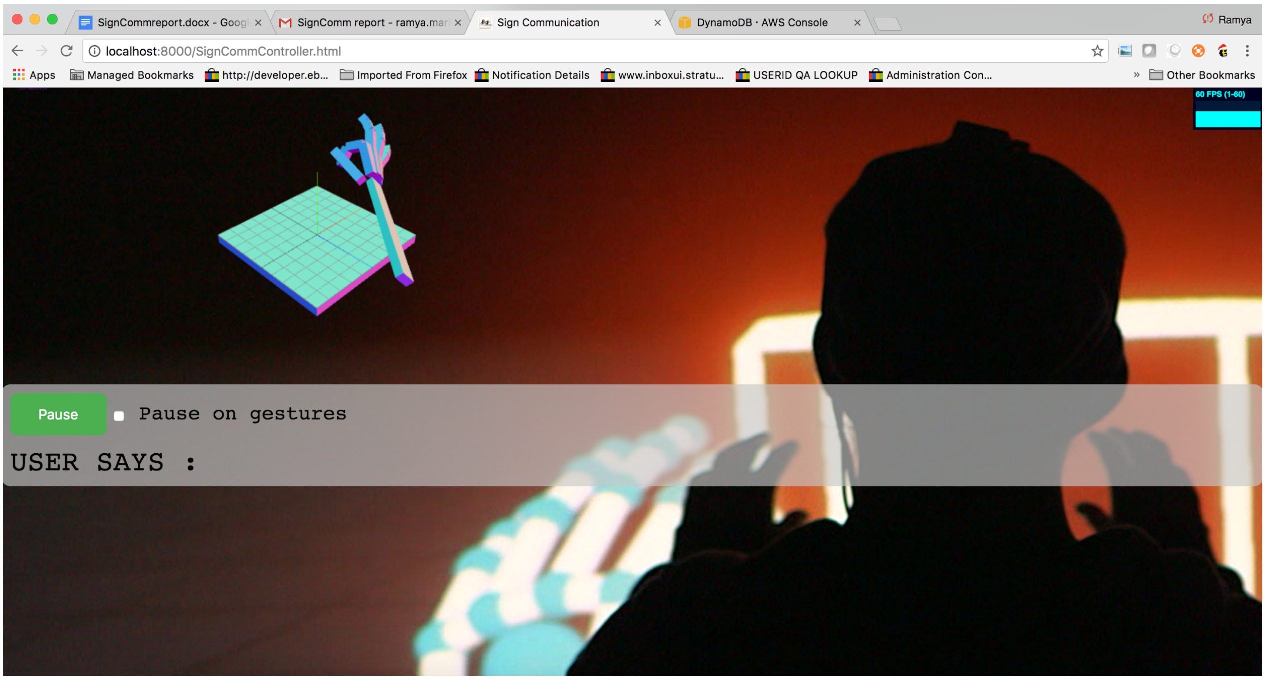
```
var indexIsClose = false;
			if(dist_thumb_index < dist_thumb_middle || dist_thumb_index <
dist_thumb_ring || dist_thumb_index < dist_thumb_pinky ){
				indexIsClose = true;
			}

			var thumbHigherThanIndex = false;
			if(thumbPosition[1] > indexFingerPosition[1]){
				thumbHigherThanIndex = true;
			}

			if(dist_thumb_index <=
FINGERS_PINCHED_X_AXIS_THRESHOLD && (yDistance <
```

```
FINGERS_PINCHED_Y_AXIS_UPPER_VALUE) && indexIsClose &&
!thumbHigherThanIndex) {
                if(!fingersPinched) {
                    debugString = "FINGERS PINCHED";
                    fingersPinched = true;
                    pinchStartZPosition = indexFingerPosition[2];
```

# Screenshots of User Interface and Gesture Dictionary

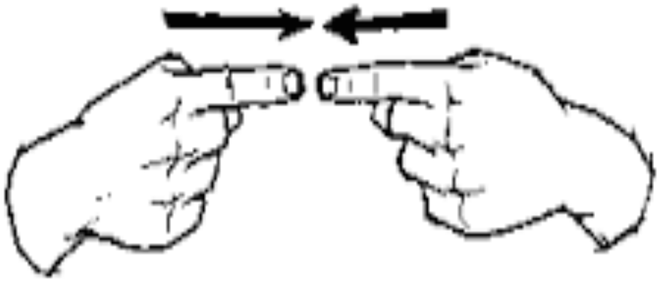



## Hi

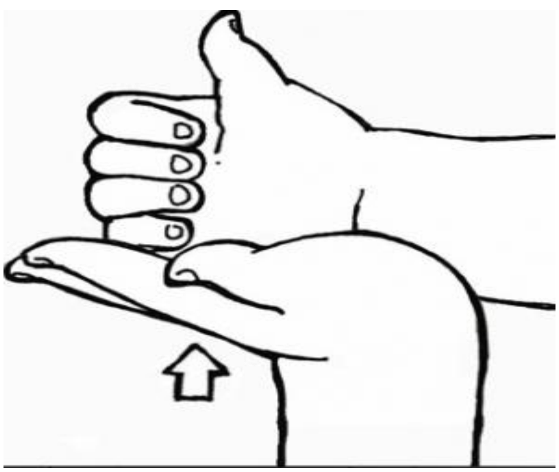
**Thank You**

**I am perfectly all right**

**Pain**



**Help**



# Technical Details

The web application can be deployed in any hardware and will support different operating systems. Front end is developed in JavaScript using the Leap Motion API and Nodejs. All the CRUD operations are performed in dynamodB database present in Amazon cloud. To connect the UI with the Dynamodb database, Node.js server is used.

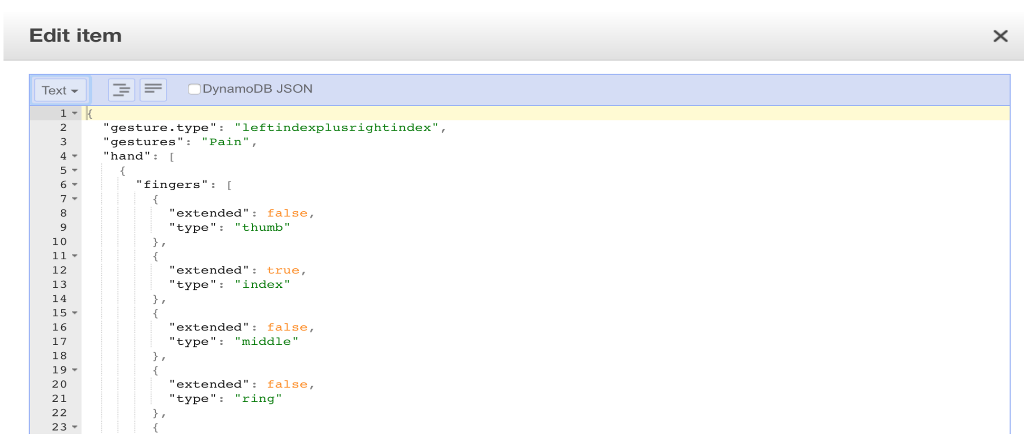
**Database** - DynamodB

Hostname - arn:aws:dynamodb:us-west-2:476360840725:table/Gestures

Amazon Dynamodb database is created with the capacity of 1.15Kb and all the users can connect to the database. The main reason behind choosing the DynamodB is that it is fast flexible and NoSQL database. It is completely managed by the cloud and supports documents and key-value store models. DynamodB is very flexible for web, mobile, gaming and other applications. For DynamodB to be accessible with the node js application we need to use the AWS SDK for JavaScript and install Node.js server on the local machine.

We can use the "scan" and "query" method to retrieve the data from the database. Query method uses the primary key attributes to retrieve the data from the table, where as the Scan method is used to scan the entire table to retrieve the information.

Sample JSON code, which we inserted in the database for the **Pain** gesture:

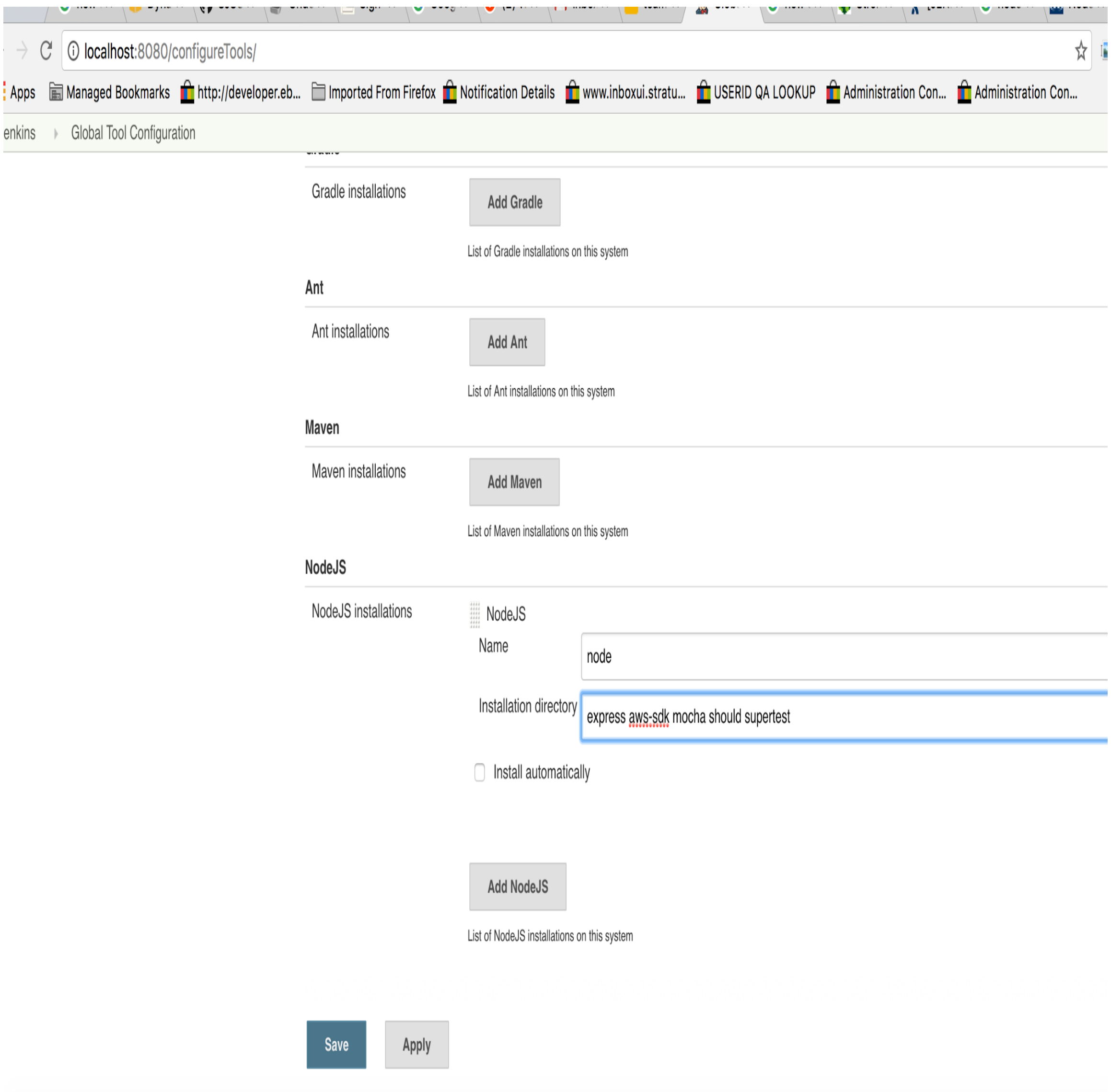


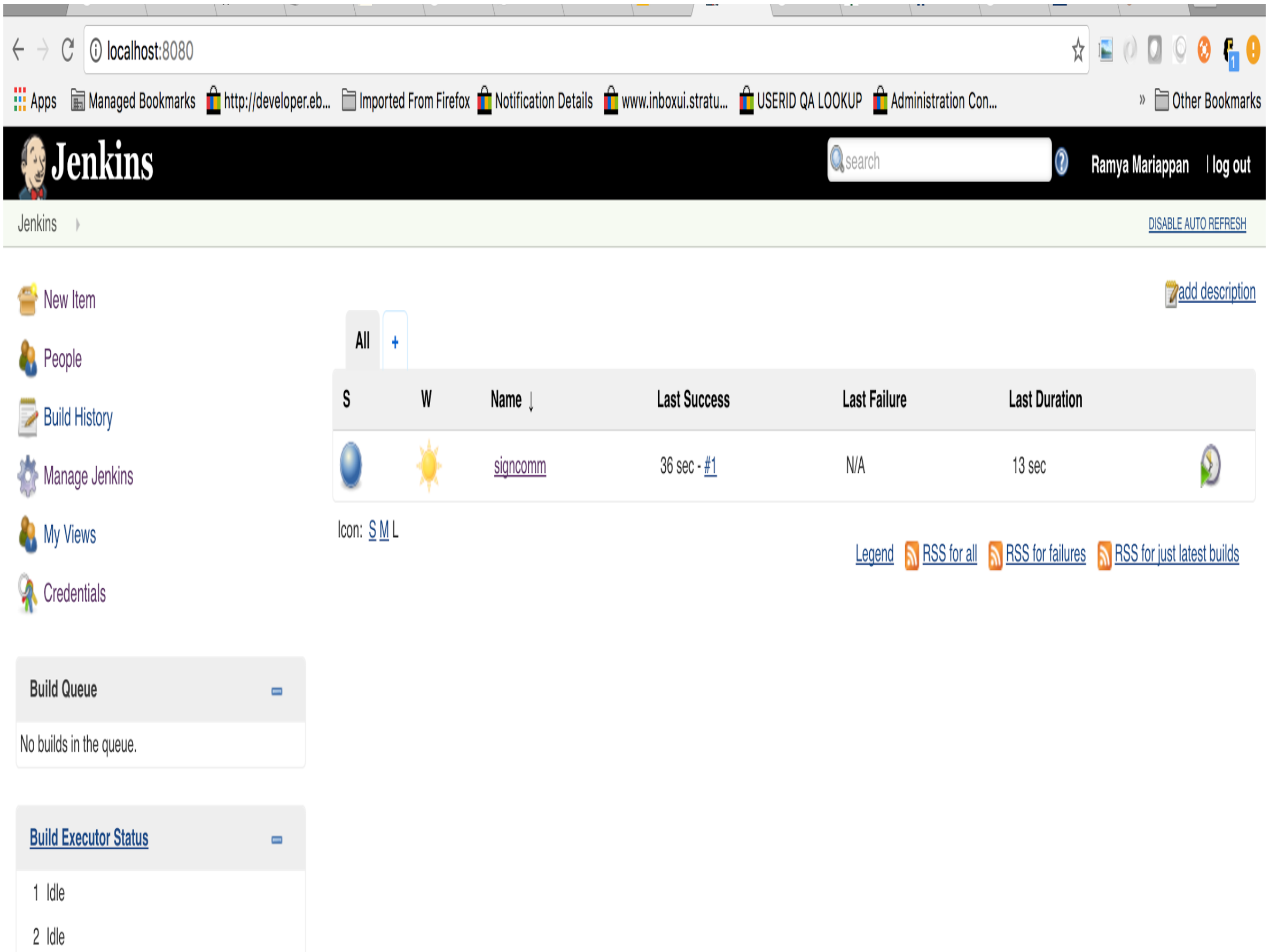


```
{
  "gesture.type": "leftindexplusrightindex",
  "gestures": "Pain",
  "hand": [
    {
      "fingers": [
        {
          "extended": false,
          "type": "thumb"
        },
        {
          "extended": true,
          "type": "index"
        },
        {
          "extended": false,
          "type": "middle"
        },
        {
          "extended": false,
          "type": "ring"
        },
        {
```

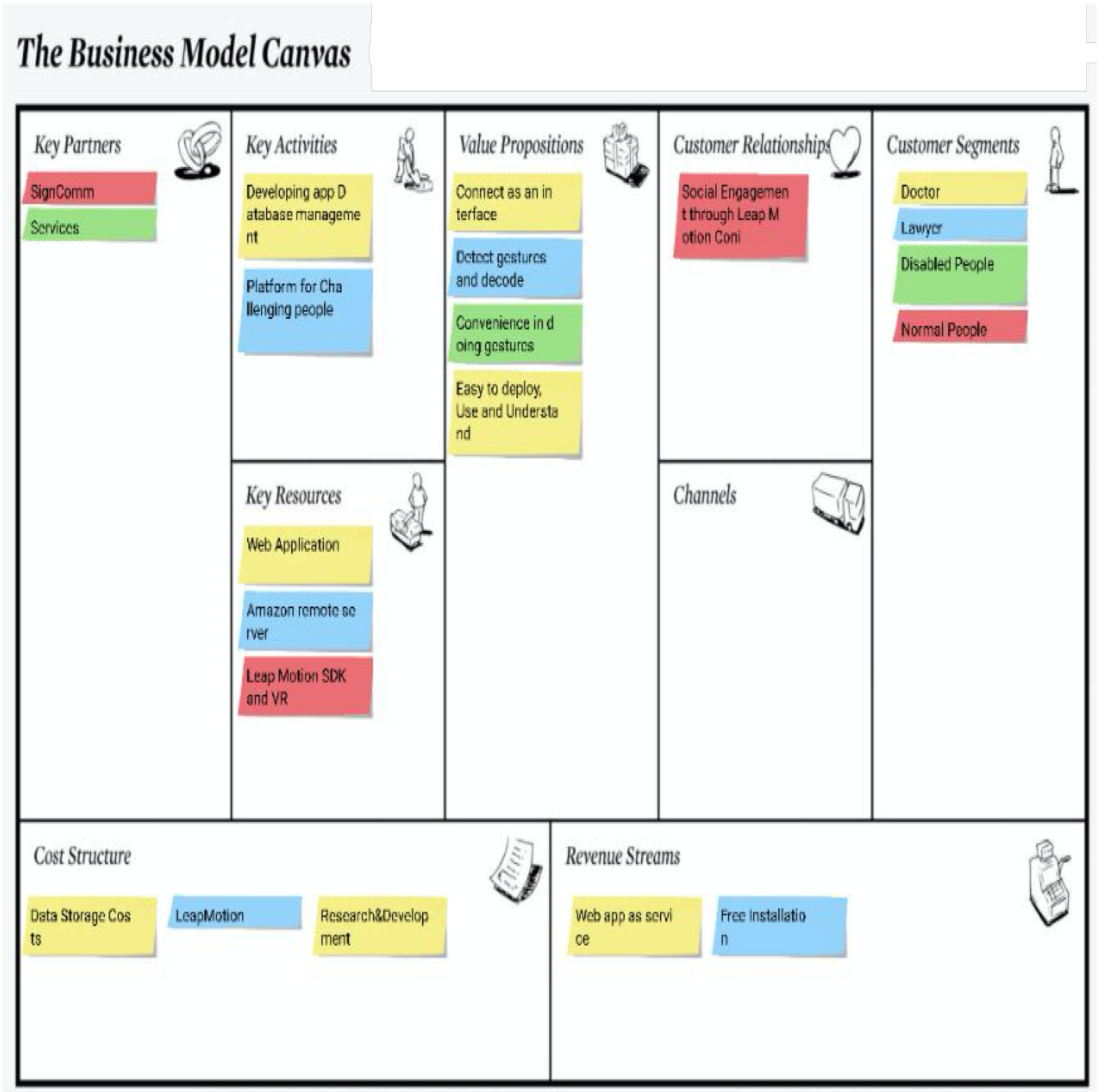
# Continuous Integration

Jenkins on Docker has been set up and this is integrated with the github plugin. The jenkins job will keep polling for code changes in github, and a new build will be triggered.This will ensure that code checkins don't result in compilation errors.




localhost:8080
Apps
Managed Bookmarks
http://developer.eb...
Imported From Firefox
Notification Details
www.inboxui.stratu...
USERID QA LOOKUP
Administration Con...
Other Bookmarks
Jenkins
search
Ramya Mariappan
log out
Jenkins
DISABLE AUTO REFRESH
New Item
People
Build History
Manage Jenkins
My Views
Credentials
add description
All
+
S
W
Name ↓
Last Success
Last Failure
Last Duration
signcomm
36 sec - #1
N/A
13 sec
Icon: S M L
Legend
RSS for all
RSS for failures
RSS for just latest builds
Build Queue
No builds in the queue.
Build Executor Status
1 Idle
2 Idle

## Business Model




The above figure represents the Business Model of SignComm Application. This model contains nine blocks in total. The figure above is the planned business model of SignComm application.

1. Key Partners
2. Key Activities
3. Key Resources
4. Value Propositions

5. Customer Relationships
6. Channels
7. Customer Segments
8. Cost Structure
9. Revenue Streams

The key partners of the application are SignComm development team and the services provided by service provider to convert the sign language (Gestures) to text format. The key activities are the essential features to build the basic prototype for the application which mainly converts sign language to text and provides database management. The application has been developed for providing the platform for challenged people. The key resources used in the initial implementation are the web application which is developed using JavaScript programming language, remote database on Amazon cloud to store JSON files.

For future enhancements, we would like to include speech converter which converts the sign to speech. Besides the key features provided by the application, the value additions planned to solve consumer needs include the ease to use interface. Target customers for the application includes individuals who are speech impaired and people communicating with them. The Leap Motion can provide service by installing and setting up in all the public places examples include Hospitals, Restaurants, Shopping malls etc. Customer relationships are very important for any web application and the main objective of developing our project is to improve the human relationships and improve the life quality of the speech impaired people .

Cost Structure of the application are the most important costs inherent to our business model. They are data storage costs, marketing and operations cost and research and development costs. As of now the free subscription on Amazon is being used to create a remote Ubuntu server and relational database, however, a feasible and cost effective data center will be used in future to store application data on go. Initially the application need to use various means to reach end users requiring an initial investment in marketing. Later customer relationships can be maintained for consistency assuming that the marketing costs will then diminish.

The application is planned to be free and delivery of products will also be free for the registered consumers. Revenues expected can be from advertisements that can be posted on the application screens. Cost Structure of the application are the most important costs inherent to our business model. They are data storage costs, marketing and operations cost and research and development costs. As of now the free subscription on Amazon is being used to create a database for storing the data in DynamoDB database, however, a feasible and cost effective data center will be used in future to store application data on go. Initially the application need to use various means to reach end users requiring an initial investment in marketing. Later customer relationships can be maintained for consistency assuming that the marketing costs will then diminish. The application is planned to be Revenues expected can be from advertisements that can be posted on the application screens.

## Research and Development

While discussing about what project to implement as the part of our course work, our main objective was to come up with a solution which is economical and which can be used further for public, and started doing research in all the areas. After brainstorming on this we came up with the idea for developing software, which can convert sign language to text.

After finalizing on the idea we noted down all the features we want to include. Later we have read some IEEE papers to analyze the current solution, which are available and learned about them. We have done research on the wearable gloves and sixth sense technologies but those are not cost effective and feasible for us to develop a project within the time limit. The main challenge for us was to decide on how to capture the gestures of the user and send that gesture to the host computer to interpret it, at first we thought of using the sensors and accelerometers to capture the hand movements, later we learned about the Leap Motion sensor.

Leap Motion sensor is mainly used for gaming purposes and it captures the body movements so we thought of using the same Leap Motion for capturing our gestures. For the front code end and to write the logic choose JavaScript programming language and Database module to contain all the application data. And thought of using Amazon web services because of the on demand processing power, storage options and ease to access it over the Internet. After deciding on the development tools to be used, we researched on existing APIs. We downloaded all the required SDKs and dependencies.

## Challenges

The main challenge we faced as a group was to first decide on what technologies to use and after deciding on the leap motion. It was difficult to stop the frames as it would capture 60 frames for second and it was in build designed developed by the Leap Motion and it was very sensitive to the light and it was sometimes very difficult to even the capture the gestures and Leap Motion sensor has slow response and it can capture only the hand movements and does not capture the body movements, sometimes small changes in the body movements would lead to huge change in the large changes, training the machine for converting signs and mapping and acquiring the data from data base is also a challenge

## Future Enhancements

We have developed an interactive web application which can be used for the speech impaired people to communicate to the world, but because of the time constrain we were able to train the machine with few gestures and converted to text form but it time permits in future we would like to enhance the project by training the machine which all possible words and convert into speech form. We would also like to integrate the current module with the other features to develop an application which can convert to a group of words to a complete meaningful sentence and deploy our entire application in cloud to make it accessible to everyone who is willing to use it.

# Conclusion

The main objective for us to develop an application which can be used by many people, we developed an interactive web application to convert the sign language to text. The system has been trained to find out the textual context for the user provided gestures with less noise. Efficient knowledge base has been created with hand gestures and matching text/description We were able to accomplish this and were able to bridge the gap between the people.

# Acknowledgements

The final outcome of this project required a lot of suggestions and numerous brainstorming sessions. We would like to thank Professor Rakesh Ranjan, CMPE 272 FALL 2016 instructor, for giving us an opportunity to work on this project and providing valuable insights and guidance throughout the course of the project. Many people, especially our teammates, classmates and friends, provided valuable comments and feedback on the project proposal. We would like to thank all those who directly or indirectly supported us in implementing this application.

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