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ROBOT ASSISTED SPEECH THERAPY

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Abstract - *The purpose of the study is the development of the language intervention content. It involves the promotion of language interaction for patients having speech language disorders using an interlocutor friend (Robot). Speech language disorders may occur due to the following reasons-*

❶*Facial paralysis* ❷ *have low muscle tone in jaw,*

❸*chick drool* ❹*have difficulty in swallowing,*

❺ *Dry mouth (Xerostomia)*

Speech language disorders can be cured by giving the speech therapy. Oral motor therapy is a part of it which involves, oral-massaging of the face (jaw, throat, chicks) through movement, strength exercise.

Here the designed interlocutor friend (Robot) has two arms in order to provide the effective massage to patient. And according to given massage pattern it gives the massage therapy. [2]

Key Words –Robot Assisted Speech Therapy, Xerostomia, Rehabilitation canter, Interlocutor friend.

INTRODUCTION -

Oral-massaging techniques are often an effective part of oral-motor therapy. These techniques focus on improving the use and function of the face (lips, tongue, and jaw) through movement, coordination, and strength exercises. Adequate oral function of the lips, tongue, and jaw is necessary to perform common activities of daily living such as eating, drinking, and speaking.

Who can benefit from Oral Massaging Techniques?

Oral-massaging techniques may benefit individuals who:

- Have facial paralysis or weakness.
- Exhibit in coordination (difficulty in coordinating muscles of the face to perform a desired function such as eating).
- Have difficulty swallowing
- Drool
- Have low muscle tone in the lips, tongue, and/or jaw.
- Experience increased/decreased oral sensation or awareness.

Why to Use Oral Massage Techniques?

- Using deep pressure or touch massage helps a person who is overly sensitive to touch become calmer and more relaxed
- Providing touch and movement information helps an individual improve awareness and oral-motor function; "wakes-up" the mouth.
- Stimulating the immediate area of touch as well as the bone structures of the face through vibration allows additional sensation that activates the vestibular system (helps an individual feel body position and movement)
- Increases facial tone and range of motion. Provides additional sensory input.
- Helps decrease pain and oral-sensitivity.
- Increases muscle response of the lips, tongue, and jaw by "waking" them up[1]

Types of Massage Used in Speech Therapy

The use of Therapeutic Speech Massage involves of several kinds of massage:

- Differential (activating and relaxation) massage based on the methods of classical massage techniques.
- Acupressure massage (of biological active points), which can be used for both activating and relaxing of the muscles.
- Massage using special devices such as speech-therapeutic probes, tongue depressors, a toothbrush, pointed tapping devices, and small finger-sized devices to stimulate the surface tissues, etc.
- Self-massage.

Massage techniques: In speech massage therapy several kinds of massage techniques used are :

1. Stroking. This is an indispensable technique that is used to begin each session. Stroking is alternated with other techniques, and each massage session ends with it. The importance of this technique is that it increases blood

circulation in the surface vessels, decreases muscle tone, and helps regulate the breathing.

There are three varied stroking techniques that are practiced in Therapeutic Speech Massage. These are the following:

a. Superficial stroking. This is the mildest, most low-impact technique - a gentle form of effleurage. It is used to reduce the tone of the muscles of the facial and articulatorymusculature.

b. Deep or embracing stroking. This is the most intensive stroking technique used to affect the receptors of the deeper muscles and vessels. It has a somewhat stimulating effect on the central nervous system.

2. Rubbing - It can be performed with the pads ofthe index and middle fingers or the thumb alone, the heel of the hand, or the entire surface of the palm. The back surface of the fingers, bent into a fist, may also be used. Both straight and spiral movements may be used.

3. Kneading - Like rubbing, this technique is performed on specific muscle groups. Kneading has the greatest muscle-activating effect of all techniques. It consists of grasping, displacing, pulling up, compressing, squeezing, pinching, and rubbing the tissues. Kneading produces the greatest increase in muscle tone and strengthens muscle contractions. This technique is in fact a form of passive exercise for the muscles and is used when the muscles show functional deficiency and decreased tone. Kneading is performed with the pad of the thumb or the thumb and index finger together or the thumb and all the other fingers together. When squeezing and rubbing, the muscles are squeezed between the pads of the thumb and fingers. The rubbing motions of the fingers may go in various directions: lengthwise, laterally, or in a semicircular or spiral pattern. In the "tweezers" kneading technique, the tissues are grasped, pulled upward slightly, and passed through the fingers. For the pinching technique, the thumb and index finger grasp the tissues superficially and make a pinching motion.

4. Vibration and tapping- Vibration alters interstitial exchange and improves tissue nourishment. Strong, hard vibration increases muscle tone while light, weak vibration decreases it. Tapping is used on the face, especially in areas where there are nerve outlets and also where there is little subcutaneous fat—for example, on the forehead, cheekbones, and mandible. The vibration technique is performed with one, two, or all the fingers, with a fluctuating motion of varying frequency and amplitude. Tapping is produced with the tips of the index and middle fingers, creating an intensive tapping motion. The movements are performed with one hand, with both hands working at once or with both hands working alternatively.

5. Light pressure on the pressure points-This technique, improves blood and lymph circulation and the metabolic processes, is used in regions where there are exit points of fascicle nerve endings. These are the so-called acupressure points. As a rule, any stroking concludes with some pressure on these points.

LITERATURE REVIEW-

The goal of neurorehabilitation is to restore and maximize physiological function, activities of daily living (ADL), and quality of life for patients with neurological disorders. Robot-assisted therapy (RT) has recently been widely investigated as an effective neurorehabilitation approach that may augment the effects of therapists' training and facilitate motor recovery. Robotic systems can not only provide external assistance to the paretic limb but also guide accurate, repetitive, and task-specific arm movements. RT is cost-effective and labor-saving; moreover, the virtual reality or gaming system that RT is equipped with can increase the motivation level of the participants and enhance engagement in the training programs.

By studying the research paper on oral massage therapy, rehabilitation robots, jaw massaging robot introduced in Japan we learnt the system related to different massaging motions also how to calculate the effectiveness of the therapy, different control system, safety consideration, location of arm, positioning of the patient.

We have also learned, how to calculate weight of the saliva by using Saxon method, from the research paper we study about maxillofacial tissue, the difference between petrissage and effleurage manipulation techniques, design concept to construct the system, temperature measurement sensor, different type of glands.

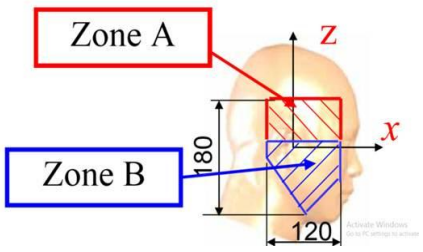


Fig-1: Parotid gland and Masseter are defined as zone. [1]

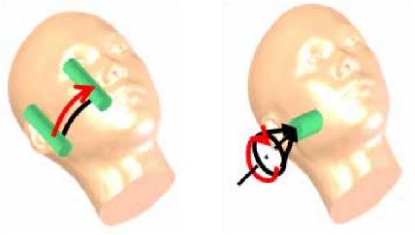


Fig.-2: Types of massage movements a) effleurage and b) petrissage. [1]

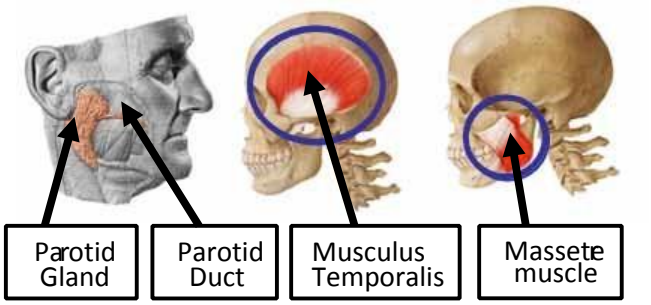


Fig-3: Maxillofacial tissue [1]

We have considered the example of dry mouth condition: The disease of dry mouth, also known as Xerostomia, is characterized by an abnormal dryness of the mouth due to the reduced capability of the patient to produce saliva. Such condition can be provoked by several reasons, such as diabetes mellitus, kidney diseases, stress, drugs, etc.
The main symptoms are dehydration, pain in the oral cavity, and the abnormalities on the sensation of tasting. The pharmacotherapy and physiotherapy are the main procedures of treatment to patients for stimulating the production of saliva. [1]

OBJECTIVES OF PROJECT –

- The main objective of the project is to have the substantial improvement in the patient having speech disorders due to various reasons (Facial paralysis, Swallowing etc.)
- To provide effective, accurate, better and easy treatment.
- To lower the workload on the speech language pathologist.
- Developing the new technologies using robotic system.
- To evaluate the efficacy of the treatment objectively.
- And will significantly impact to know the methods, technologies and address critical barriers to progress into this field.
- The important objective is to provide the treatment in affordable price in addition with operability by lay-man.

METHODOLOGY –

❖ **Defining the problem** –
- Identifying the purpose of the construction.

❖ **Researching** –
- Gathering Information.
- Conducting the Interviews.
- Observing.

❖ **Designing** -
- Mechanism.
- Programming.

❖ **Creating a Prototype** -
- Testing the design.
- Troubleshooting the design.

❖ **Building Our Robot** –

❖ **Testing and Evaluation** -
- Evaluation of design.
- Evaluate the planning process.

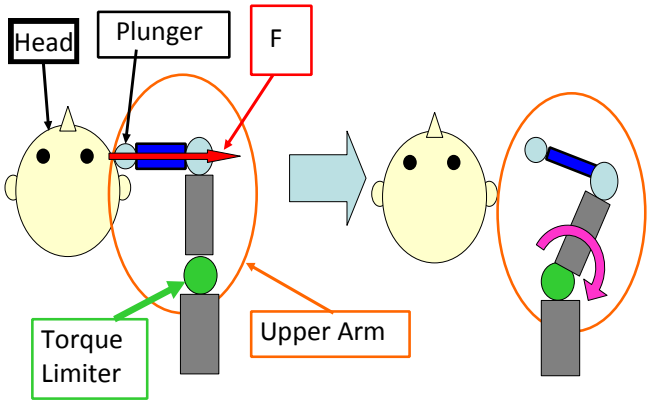
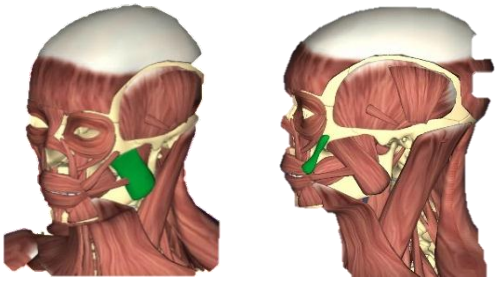


Fig-4: Basic Construction [1]

SYSTEM DESCRIPTION -

In order to provide effective massage to patients, the development of System is based on the following design specifications:

1. Working Area: As we described previously, the target organ of the massage therapy for dry mouth is parotid gland. Similarly, temporal and masseter muscle are deemed as the target of massage for TMJ disorders. Therefore, the working area of system should be designed to anatomical structures.



Masseter Muscle L Zygomaticus Major L

Fig- 5: Working Area

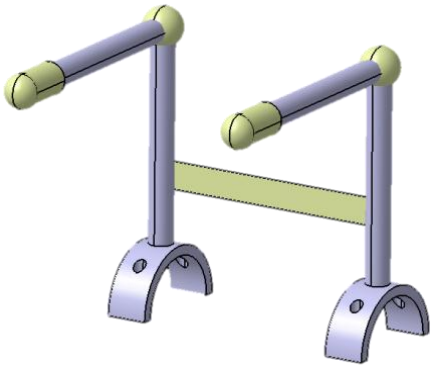
2. Mechanism: In order to perform massage on both Zone A and Zone B, the system mechanism should consist of two-arm manipulators that are utilized to control the position/orientation of plunger devices (attached to the end-effector). Of course, it is desirable that the driving mechanism of the arms is located out from the patient's visual field.

3. Applied Force: Using a head model that we will describe later, we measured the dynamic force on patient's head during the massage of maxillofacial region by skilled physiatrician. Thus, we defined a maximum force of 30Nto massage around patient face. Therefore, WAO-1 designed to apply the same force to physiatricians.

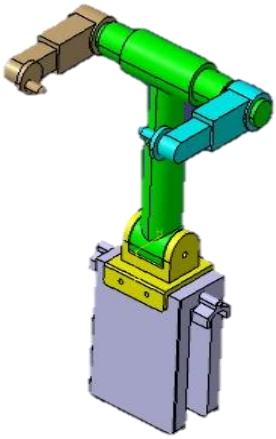
PROPOSED MODELS –

In order to meet the above requirements of working area, mechanism, applied force various designs were proposed at first, then 4th design is fixed as final design

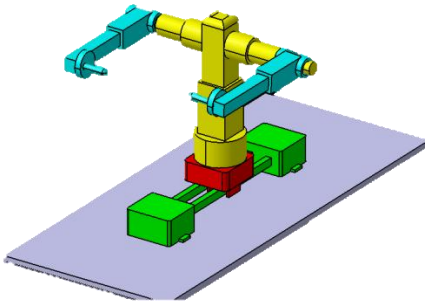
1] 1st proposed design with shoulder mounting-



2] 2nd proposed design with mounting on bed-



3] 3rd proposed design with mounting on floor -



4] FINAL DESIGN with mounting on chair-

Fig-6: Proposed Models

MECHANICAL COMPONENT LIST-

Sr.No.	Component	No.
1.	Nylon Roller	4
2.	Spring	2
3.	Coupler	4
4.	Flexible Coupler	1
5.	Aluminum Pipe 18x18x150	2
6.	Aluminum Pipe 25x25x300	2
7.	Bearing Bush	4
8.	Linear Bearing LM8UU	4
9.	Guide Rod M.S.8X600	2
10.	Lead Screw M.S. 8X300	2
11.	Lead Screw S.S. 8X150	1
12.	Motor 10rpm	2
13.	Motor 150rpm	3
14.	Motor 100rpm	1
15.	Slider 10inch	1
16.	Slider 18 inch	2
17.	Sheet Metal Structures	4

ELECTRONIC COMPONENTS & THEIR SPECIFICATIONS-

Components	Specification
	**Arduino nano:** Operating voltage =+5 V Flash memory = 32KB SRAM = 2KB EEPROM = 1 KB Frequency (Clock Memory) = 50Hz
	**12 Volt D.C. Motor :** DC supply =+ 4 to +12 V Gear Assembly – Spur Brush Type – Precious Metal
	**Motor Driver Controller LN298N:** Double H bridge Drive chip = L298N Operating Voltage = 5~35 V Peak Current = 2 A No. of Channels = 2
	**Joystick:** Operating Voltage = 5 V Dual axis XY Joystick Module
	**Push Button Switch (PBS110D) :** Contact Form: SPST OFF - (ON)Contact Rating = 1A @ 125VAC No. of Pins - 2
	**Resistor:** Pull up Resistor 4.7K Ω

	**Potentiometer:** Type – Rotary a.k.a. Radio POT Resistance Value = 10 K Power Rating = 0.3 W Rotational Life = 2000K Cycles
	**SMPS:** Switched mode power supply 230 V to 12v – 5v

The detailed specification of the Aurdino Nano board is as follows:

- Microcontroller ATmega 328
- Operating Voltage (logic level): 5V
- Input voltage (recommended) : 7-12V
- Digital I/O pin: 40mA
- Analog Input pins 8
- Dc currents per I/O pin: 40mA
- Flash memory 32 KB (ATmega 328) of which 2KB used by booth loader
- SRAM: 2KB (ATMega328)
- EEPROM:1 KB (ATmega328)
- Clock speed: 16 MHz

OPERATIONAL DEFINITION –

The operation is done by following flow-

1. The patient puts his/her head at position to the robot to receive the massage

2. Then as per requirement the target organ of massage therapy, the pattern of the massage and amount of pressure and other required quantities are fed to the system.

3. In order to perform the massage the required positions, motions, orientations are also given to the arm manipulators.

4. After all the settings robot starts giving the massage for the given specific interval of time.

CIRCUIT DIAGRAM:

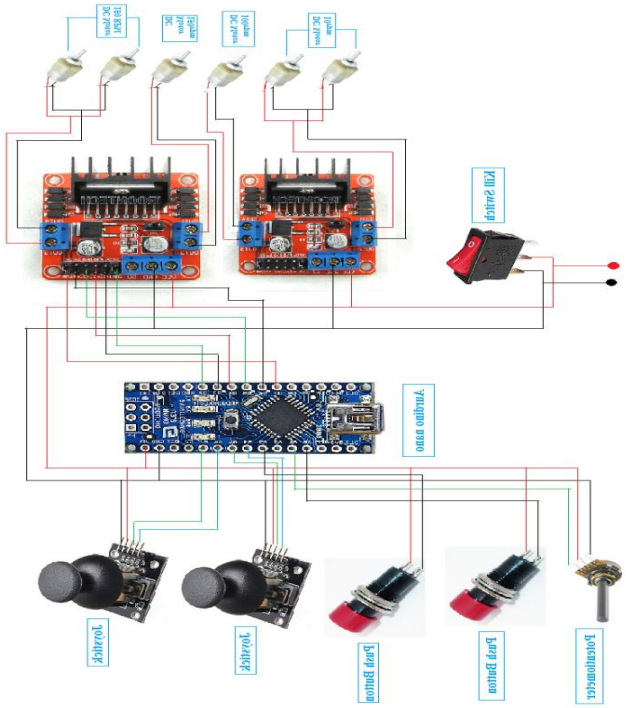


Fig-7: Circuit Diagram

FLOW CHART –

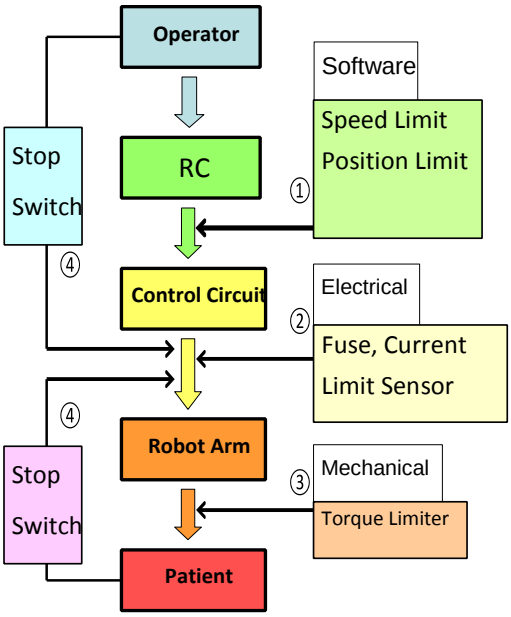


Fig-8: Flow Chart

TESTS-

The efficacy of the treatment provided by the robot in assistance with the speech language pathologists to the patient can be measured with the help of following tests. [1]

1. Saxon Test:

The production of saliva was considered as performance index. This index is measured by using the Saxon test, which is a standard method to confirm the effectiveness of the massage therapy. In this test, gauze is put into subject's mouth for two minutes, and the weight of saliva is then measured. The massage experiment is conducted by the following flow.

1. The subject lies and put his / her head on the robot to receive the massage for 5 minutes.

2. After 5 minutes rest, the Saxon test is performed for 2 minutes.

3. The subject rest for 5 minutes.

4. The massage for parotid gland is provided and Saxon test is performed.

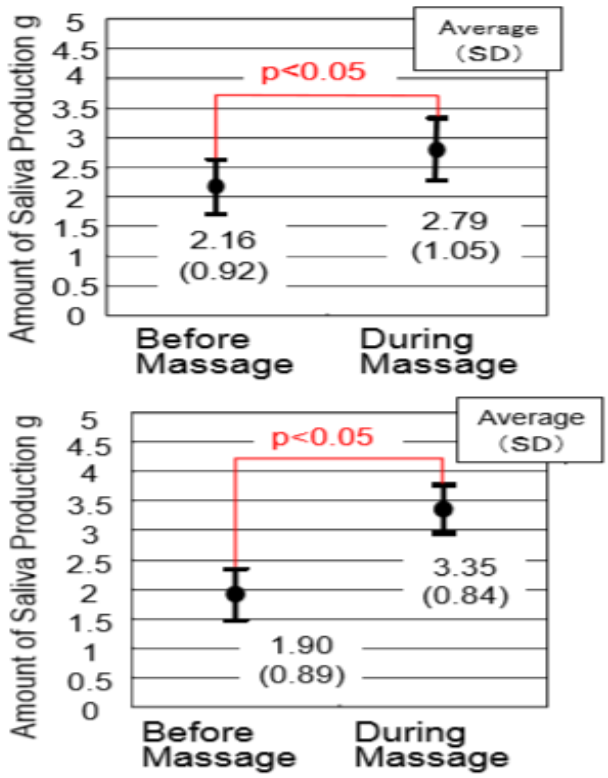


Fig-9: Saxon Test Result

The experimental results are shown in Fig.1. As we can observe, the average production of saliva was increased by 0.63 [g] after providing the massage. By analyzing the collected data with a t-test, we found a significant difference ($p < 0.05$). Thus the effectiveness of the massage to the parotid gland by WAO-1 is confirmed. On the other hand, when the doctor gives the massage to the parotid gland of the people, production of saliva increases 1.4 [g] (average of 6 people). Therefore, the effect of WAO-1's massage is less than that of doctor's massage.

2. Ultrasonography:

In this experiment, robot provides massage to masseter muscle for 2 minutes. During these 2 minutes, the massage is provided to the upper part of the masseter muscle and the lower side of the masseter muscle. The skin temperature and size of masseter is measured before and after the massage. Skin temperature is measured by the thermal camera before, just after, 10 minutes after and 20 minutes after the massage. Size of masseter muscle is measured by the ultrasonography before and just after massage.

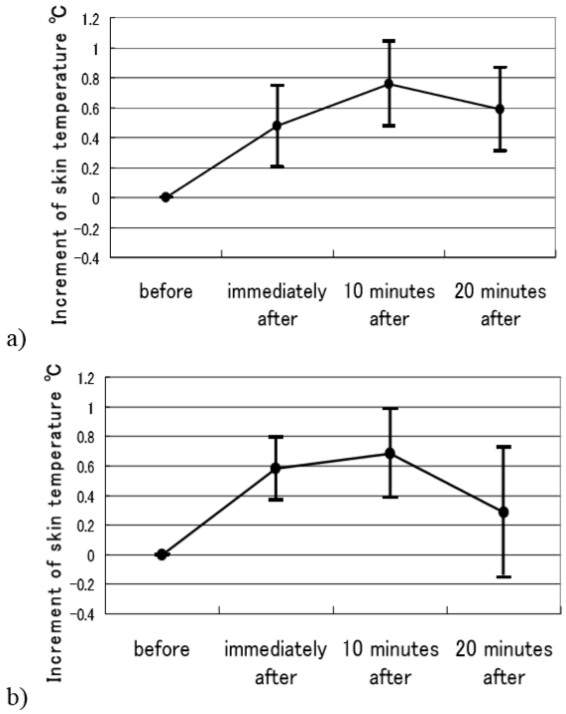


Fig-10: Ultrasonography Test Result

The temperature of facial skin is shown in Fig. 2 and the size of masseter is shown in Fig. 3. As a result of the massage of WAO-1, the temperature increases immediately after the massage, and keeps rising until ten minutes later. The

amount of an increase after ten minutes was 0.8[Co]. Increase rate of the size of masseter muscle has increased 16.8%. As a result of the massage of doctor, increase rate of the masseter muscle size has increased 18.7%. In both cases, an increase was found. However, there was so no difference on the increase rate.

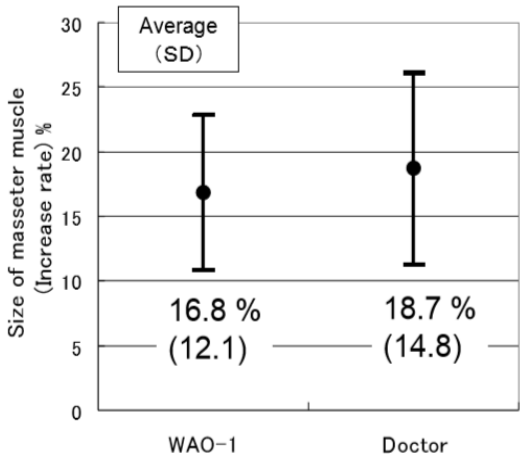


Fig-11: Ultrasonography Test Result

REVIEWS OF SPEECH THERAPIST:-

We have visited to following speech language pathologists -:

1. Dr. Shilpa Huzurbazar (Sanwad Clinic Bhendi lane Shivaji Putala, chowk Kolhapur, Maharashtra, India)

2. Dr. Arjun Maruti Patil (Swaranginee Rehabilitation Center Rajarampuri 4th lane Kolhapur, Maharashtra, India)

Speech therapy is used to stimulate the muscle tone of human. During oral motor exercise the stiffness or looseness of muscle is recovered in child. Due to this the muscle placement of the patient is satisfactory. In speech therapy various massage techniques are used such as rolling, kneading, tapping, hacking, pinching to stimulate the brain actions, in this project they have covered rolling and muscle relief massage technique.

In today's world disorders in speech therapy is increased hence day by day the necessity of oral motor is going on increasing so this project help us to attend maximum patients.

ADVANTAGES:

1) High accuracy.
2) Easy treatment.
3) Reduces the workload on the speech language pathologist.
4) Helps to evaluate the efficacy of the treatment.
5) Reduces the time required for the treatment.
6) It is Profitable.
7) It is universal, portable and flexible.

SAFETY FEATURES OF OUR ROBOT -

- Emergency Kill Switch.
- Spring mechanism for homogeneous pressure and auto-alignment.
- Replaceable neoprene roller covering with powder coating to avoid skin infection.
- Right angled sitting position for covering maximum targeted area during the treatment.

CONCLUSIONS-

We have concluded that the various syndromes like cerebral palsy and Down syndrome and also some disorder like Xerosthomia, drool, muscles looseness and tightness etc can be effectively cured by robot by giving speech massage therapy in assistance with speech language pathologist. Also, we have achieved,

1. The numbers patients attended by the pathologist are increased.
2. Workload on speech language pathologist is also decreased.
3. Pathologists are able to measure the efficacy of their treatment objectively.
4. The time required for treatment is reduced considerably.
5. Accuracy of treatment is also increased.
6. Unskilled person can also handle this project easily.
7. Cost effective.

By considering these all the above point and verification giving by Dr. Arjun Patil (DSC [HI], PGCCAT speech therapist) we conclude that this product can be used in every speech rehabilitation center also.

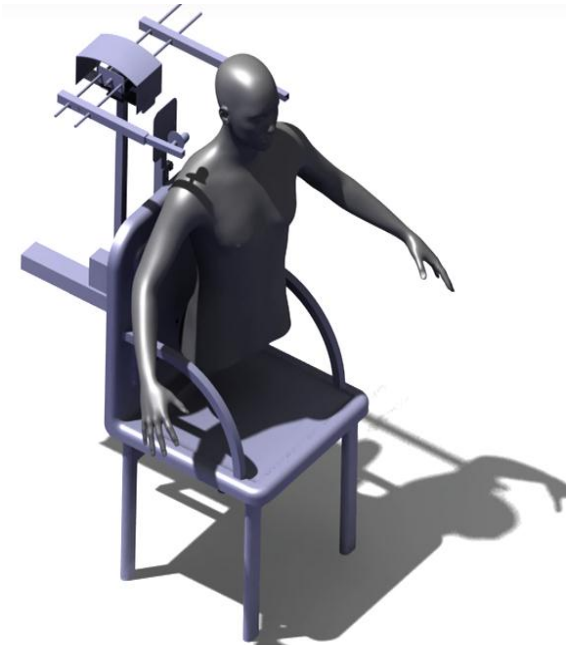


Fig-12: Speech Therapy Robot Design

Fig-13: Speech Therapy Robot

ACKNOWLEGEMENT:-

We would like to thank our teacher Prof. N.V. Deshpande for his keen interest and valuable guidance and continuous encouragement throughout the development of this project work. Also We would like to thank Dr. Shilpa Huzurbazar. [Sanwand Hospital], Dr. Arjun Maruti patil. [Swaranginee rehabilitation center] for giving us their valuable time and information regarding this project.

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