International Journal of Electronics Engineering Research.
ISSN 0975-6450 Volume 9, Number 7 (2017) pp. 1013-1026

http://www.ripublication.com

Design of Bio-Medical Embedded System for Tremor Analysis

Bhamidi Rama[1]

[1]Department of Electronics Technology
Loyola Academy Degree & PG College
Old Alwal, Secunderabad 500 010
Telangana, India

I.V. Subba Reddy[2*]

[2]Department of Physics, GITAM University-Hyderabad Campus,
Rudraram, Medak 502 329 Telangana, India

**Corresponding author*

Abstract

Tremor is an involuntary action caused due to contraction of muscles. Doctors diagnose the illness of a patient based on tremor, as it is considered to be an important clinical symptom. Normally in medical diagnosis the method used presently to identify the tremor is Electromyography recorders (EMG), these readings depend on the emotions of the patient. So readings should be taken when the patient is in calm and stable state. The instrument is not easily portable because of its large size. These conditions definitely impose certain limitations on the utility of EMG in the diagnosis of tremors in patients. To overcome such limitations, the authors tried to propose and design a novel embedded system in which the average intensity over the measurement interval is recorded. The device is also highly portable for long-term measurement and recording of tremor movements. The measured tremor signals from MEMS sensor (accelerometer) through a Microcontroller are displayed on a 2×16 LCD (liquid crystal display), at the same time the tremor signals are transmitted to remote places, using MAX 232 IC and RS 232. A serial communication is achieved between Personal Computer and the microcontroller. This microcontroller based portable embedded system for tremor analysis is a very innovative development in bio-medical field which can be used in the hospitals for diagnosis applications. The developed system consists of a MEMS sensor (accelerometer), RF (radio frequency) module, 2×16 LCD display, and microcontroller with PC (personal computer) interface. The MEMs sensor readings along X-axis and Y-axis for different age groups are taken and a Statistical Software tool IBM SPSS 20.0 VERSION is used to analyze the readings. The overall power consumption of the prototype board is also calculated and found to be 0.218 watthour.

Keywords: RF, MEMS, Microcontroller, Tremor, Patient, SPSS software, power consumption.

I. INTRODUCTION

Tremor is one of the most important clinical symptom which must be taken care during the diagnosis of the patients. Tremors also play a vital role in vitreoretinal surgeries done by the doctors, because a small shake in hand will cause vision loss. This disease occurs in persons having mental tensions or stress in their mind. Tremors are also caused due to problems in some parts of the brain, which controls the muscles in the body. Neurological disorders that produce tremors include multiple sclerosis, stroke, traumatic brain injury and neurodegenerative disease. In these types of disorders parts of brain stem gets damaged. The other cause is due to the use of some types of drugs. The symptoms include a rhythmic shaking in the hands, arms, head and legs. Some of them have difficulty in writing, drawing and problems in holding things like utensils or fork. Some types of tremors are Parkinson’s, Essential, Dystonic, Cerebellar, Psychogenic, Orthostatic tremors. Parkinson’s tremor is commonly said to be of two types -Physiological and Pathological tremors. Physiological tremors can occur due to various disorders such as tumors in brain and also in patients who are addicted to drugs. Pathological tremors are due to hyper thyroid and emotional stress.

Tremors cannot be cured. The treatment depends on accurate diagnosis of the cause. Some types of tremors can be reduced, when the problem is identified at an early stage, so that it disappears.

A three dimensional accelerometer sensor is used to measure the hand motion which measures the motion of the hand using three single axis accelerometer made of semiconductor [1]. The output of the sensor which is displacement is sensed using differential capacitors.

The features of PSD process, based on the application of cumulants and polyspectra representing different types of tremors and can stand as the basis for recognition between them is done [2].

S.P.N.Singh [3] used an instrumented surgical tool, high-precision recordings of hand tremor were taken during vitreoretinal microsurgery. The data obtained using a compact, custom six-degree-of-freedom inertial sensing module is filtered and analyzed to characterize the physiological hand tremor of the surgeon.

The magnitude and frequency of eye motions were recorded by taking photographs of blood vessels of the eye. Simultaneous tracks of head and eye motions show that the rapid eye motions are independent of head motion according to G.C.Higgins [4].

The oral dosage of caffeine and propanol effects is studied in order to reduce physiological surgeon hand tremor. A test was done on 17 ophthalmic surgeons for 3 separate days and their hand tremor is measured using MADSAM, a high resolution non contact position tracking system[5].

An attempt was made to check if propanol can decrease the surgical tremor and anxiety in residents performing ocular microsurgery without causing any problem to the patient, a 40mg medicine was induced 1 hour before performing the surgery and found that it has a highly significant effect in decreasing the anxiety [6].

This paper reports [7] the development of a robotic system to perform a small scale (sub millimeter) manipulation task requiring human judgment, sensory integration & hand eye co-ordination.

This paper [8] describes the development and initial testing of a new and optimized version of study hand manipulator of retinal surgeries. In this approach, Steady -hand micromanipulation, tools are held simultaneously both in the operator's hand and a specially designed actively, Controlled robot arm. The robot controller senses the forces and uses this information to provide smooth, trimmer free, precise positional control and force scaling.

II. THE PROPOSED WORK

The proposed tremor monitoring system consists of a prototype board having transmitter and receiver sections. When the device is switched on, the position of the MEMS sensor is taken as the first value. The MEMs sensor is placed on the wrist of the patient and readings are taken in four different positions-free position, without load in the hand, with load in the hand and stretch position, along the X-axis and Y-axis. If any tremors are observed, the sensed output is given to LM392 which has an operational amplifier and voltage comparator inside the IC. The compared difference is given to the microcontroller, Where it will perform the task that is specified in the program. Microcontroller will send the readings of the patient using the transmitter and the LCD will display whether tremor has occurred or cured.It also displays accurate analog values of X-axis and Y-axis and at the same time the microcontroller will send the signals to RF transmitter. The RF transmitter will convert these signals into radio frequency signals. These RF (Radio Frequency) signals are transmitted by the transmitting antenna.

The signals which are transmitted by the transmitting antenna will be received by receiving antenna and the data will be given to the RF receiver. The chosen pair of RF transmitter and RF receiver will consist of same address lines, data lines and frequency. The range of communication between transmitter and receiver is 50-100 meters. The received signals are given to the microcontroller. Microcontroller will perform the task according to the developed code. SPSS 20.0 software is used to analyze a sample of 251 readings taken on patients of different age groups and observed the impact of tremor in four different positions.

III. SYSTEM FOR IMPLEMENTATION

It consists of two sections- transmitter and receiver section, the power consumed by these two sections is calculated as 218.44 mW. It is the minimum power utilized even when the equipment is used for 1 hour, the energy consumed will be 0.218 Watt hour.

A. Transmitter Section

The power supply section will convert 230 V AC to 5 V DC which is required for the microcontroller and other components. The MEMS sensor (MMA 7361- 3 axial accelerometer) will sense $1/10^{th}$ degree of variation in 3 dimensional plane. It is a digital sensor which has got an inbuilt A/D converter and its output value is given to the LM392. A comparator has been set with a reference voltage of 5 V and it is used to compare the voltages that are acquired from MEMS sensor. Hence the voltages are compared and given to the microcontroller (AT89S52). Microcontroller performs all the tasks in accordance with the program. Microcontroller used is a 40 pin IC, in which 32 pins are the input/output lines. The LCD display is used to display the status of the patient which is acquired from the microcontroller and at the same time, the signals are transmitted from RF transmitter. The frequency of RF transmitter is 434 MHz. The RF transmitter consists of IC-HT12E which is used to encode the signals. This IC is capable of encoding 12 bits.

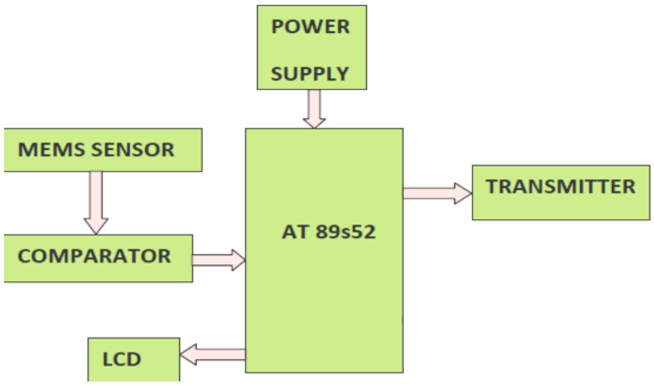

Fig.1. Block diagram of Transmitter

B. Receiver Section

The power supply section will provide 5 V DC to the microcontroller and other components in the receiver section. The transmitted signals from the RF transmitter are received by the RF receiver and given to the microcontroller (AT89S52). The frequency of RF receiver is 434 MHz. This RF receiver consists of HT12D IC which is used to decode the signals. This IC is capable of decoding 12 bits. The chosen pair of transmitter and receiver section have same address lines, data lines and frequency. Here it has 12 address lines and 4 data lines. By using MAX 232 IC and RS 232 cable, data is transmitted between microcontroller and Personal Computer using serial communication.

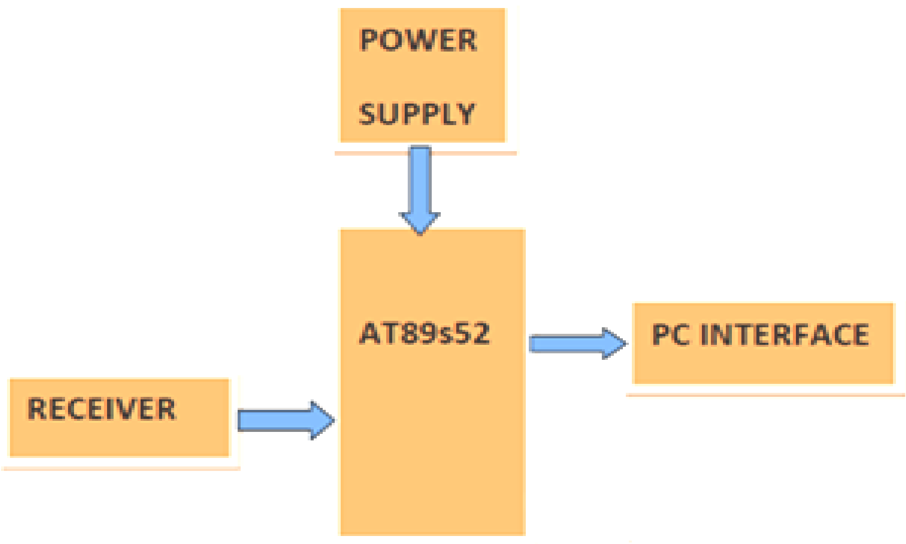

Fig.2. Block diagram of Receiver

IV. HARDWARE

The prototype development board reveals the entire hardware of an embedded system.

Fig.3. Prototype development board

V. STATISTICAL ANALYSIS

Samples are collected for different age groups of patients in the hospital having different problems. The readings are taken in four different positions of the right hand. The readings consists of analog-X value and analog-Y values. Analysis is done on both X-axis and Y-axis readings, which are taken for different combinations.

A. Free position:

In this position the elbow is at rest position and from the wrist the fingers are left free. The sensor is placed at the wrist and the readings are taken.

B. Without load position:

In this position the elbow is at rest position and from the wrist the fingers are stretched. The sensor is placed near the wrist and the readings are taken.

C. With load position:

In this position the elbow is at rest position and load is added near the palm. The sensor is placed near the wrist and the readings are taken.

D. Stretch position:

In this position the hand is kept in straight position. The sensor is placed near the wrist and the readings are taken.

All these positions are shown below

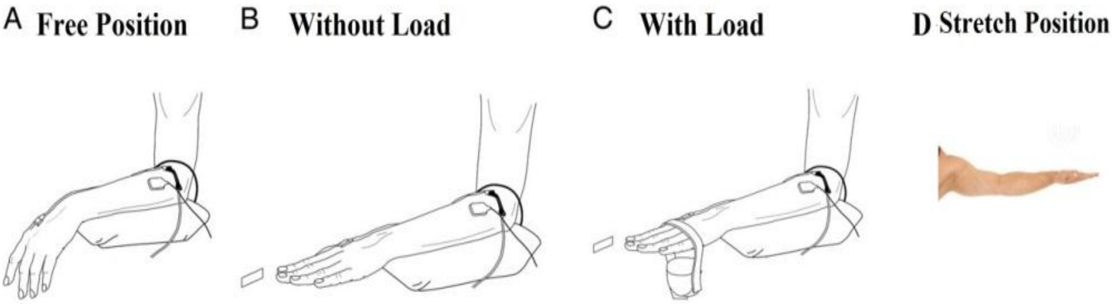

Fig.4. Positions

A total of 251 samples for different age groups of patients are collected. The data consists of 32% of samples with < 20 years age, 27.5 % with 20-30 years of age group,19.9 % with 30-40 years of age group and 20 % are > 40 years of age. The sample consists of 54 % of males and 46 % of females. The data which is taken is a secondary data and the variables are assumed as follows

Patients with different ages are classified as follows-
Patients with age <20 years are group-1, 20-30 years age group-2, 30-40 years age group-3 and >40 years are group-4. Similarly male patients are labeled as 1 and female as 2.

The following statistical analysis is applied on the samples:

A. Hypothesis:

A quantitative statement about a population is called hypothesis. Hypothesis is of two types-null hypothesis and alternative hypothesis.

- Null hypothesis: It is defined as the hypothesis under verification and is denoted by H_0 and is always set up for possible rejection under the assumption that is true.
- Alternative hypothesis: It is defined as the hypothesis which is likely to be accepted in the event of rejection of the null hypothesis H_0 and is denoted by H_1 or H_a.

B. Errors in testing of hypothesis:

A decision is taken after a test is applied about the acceptance or rejection of null

hypothesis against an alternative hypothesis. The decisions are of four types.
But the first two decisions are called errors in testing of hypothesis

i) Type-I error: It is the error committed if the null hypothesis (H_0) is true but the test rejects.

ii) Type-II error: It is the error committed if the null hypothesis (H_0) is false but the test accepts.

- Level of significance:

The level of significance is denoted by α and is said to be the maximum probability of committing type-I error

α = P (Committing Type-I error)
= P (H_0 is rejected when it is true)

- Power of the test:

The power of test is defined as the probability of rejecting a false hypothesis and is denoted by $1\text{-}\beta$**.**

Power of the test = P (H_0 is rejected when it is false)
= 1- P (H_0 is accepted when it is false)
= 1- P (Committing Type-II error)
= $1\text{-}\beta$

A test in which both α and β are small and kept at minimum level is considered desirable. If the sample size is increased then both α and β can be reduced.

C) One tailed and two tailed tests:
A test with the null hypothesis $H_0 : \theta=\theta_0$ against the alternative hypothesis $H_1 : \theta\neq\theta_0$, it is called a two tailed test.

A test with the null hypothesis $H_0: \theta=\theta_0$ against the alternative hypothesis $H_1: \theta>\theta_0$ (right tailed alternative) or $H_1: \theta<\theta_0$ (left tailed alternative) is called one tailed test.

D) Procedure for testing of hypothesis:

- Set up a null hypothesis i.e. $H_0 : \theta=\theta_0$.
- Set up a alternative hypothesis i.e. $H_1 : \theta\neq\theta_0$ or $H_1: \theta>\theta_0$ or $H_1 : \theta<\theta_0$
- Choose the level of significance, α.
- Select appropriate test statistic Z. Select a random sample and compute the test

statistic. Calculate the tabulated value of Z at α % , Z_α

- Compare the test statistic value with the tabulated value at α % and make a decision whether to accept or to reject the null hypothesis.

E) Large sample tests:

The sample size which is greater than or equal to 30, is called as large sample and the test depending on large sample is called large sample test.

The assumption made while dealing with the problems relating to large samples are

Assumption-1: The random sampling distribution of the statistic is approximately normal.

Assumption-2: Values given by the sample are sufficiently closed to the population value and can be used on its place for calculating the standard error (SE) of the statistics.

F) Large sample test for difference between two means: If two random samples of size n_1 and n_2 are drawn from two normal populations with means μ_1 and μ_2, variances σ_1^2 and σ_2^2, respectively.

Let $\bar{x}_1$ and $\bar{x}_2$ be the sample means for the first and second populations , respectively.

Then $\bar{x}_1 \sim N\left(\mu_1, \sigma_1^2 / n_1\right)$ equ. 1

and $\bar{x}_2 \sim N\left(\mu_2, \sigma_2^2 / n_2\right)$ equ. 2

Therefore $\bar{x}_1 - \bar{x}_2 \sim N\left(\mu_1 - \mu_2, \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)$ equ. 3

For this test the null hypothesis is $H_0 : \mu_1 = \mu_2 \Rightarrow \mu_1 - \mu_2 = 0$ against the two sided alternative $H_1 : \mu_1 \neq \mu_2$. Now the test statistic

$$Z = \frac{t - E(t)}{S.E(t)} \sim N(0,1) = \frac{(\bar{x}_1 - \bar{x}_2) - E(\bar{x}_1 - \bar{x}_2)}{S.E(\bar{x}_1 - \bar{x}_2)} \qquad \text{equ. 4}$$

$$\Rightarrow Z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{S.E(\bar{x}_1 - \bar{x}_2)} \sim N(0,1)$$

$$\Rightarrow Z = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \sim N(0,1) \qquad \text{equ. 5}$$

[Since μ_1-μ_2 = 0 from H_0], now calculate $|Z|$

Then find out the tabulated value of Z at α % i.e. Z_α *If* $|Z| > Z_\alpha$, reject the null hypothesis H_0, If $|Z| < Z_\alpha$, accept the null hypothesis H_0.

The following tests are done for various combinations of data taken

t-test

This test gives the significant difference between two means. It is calculated using ratio of difference between two dispersion of values. The t-test is positive if the first mean is larger than second and negative if it is smaller.

f-test

It is a technique to test the significance between two variances at a time. It is the squares of two scaled sums of squares reflecting different sources of variability. The advantage of f-test is that there is no needs to pre specify which treatments are to be compared and need not be adjusted for multiple comparisons.

RESULTS

The variation for different positions of hand is shown in table. 1

Table 1.

S. No.	Hypothesis (t-test)	Significant values	Conclusion
1(a)	H_1: There is a significant difference between the variables with load X and without load X	0.001	Reject H_0
1(b)	H_0:Thereis nosignificant difference between the variables with load Y and without load Y	0.134	Accept H_0
2(a)	H_0: There is no significant difference between the variables with load X and free position X	0.194	Accept H_0
2(b)	H_1: There is a significant difference between the variables with load Y and free position Y	0.004	Reject H_0
3(a)	H_1: There is a significant difference between the variables with load X and stretch position X	0.02	Reject H_0
3(b)	H_0: There is no significant difference between the variables with load Y and stretch position Y	0.976	Accept H_0
4(a)	H_1: There is a significant difference between the variables free position X and without load X	0.022	Reject H_0

4(b)	H_1: There is a significant difference between the variables free position Y and without load Y	0.046	Reject H_0
5(a)	H_0: There is no significant difference between the variables without load X and stretch position X	0.337	Accept H_0
5(b)	H_0: There is no significant difference between the variables without load Y and stretch position Y	0.302	Accept H_0
6(a)	H_0: There is no significant difference between the variables free position X and stretch position X	0.196	Accept H_0
6(b)	H_1: There is a significant difference between the variables free position Y and stretch position Y	0.005	Reject H_0

Table. 2 shows the variation for different positions with respect to different age groups.

Table 2

Sr. No.	**Hypothesis (f-test)**	**Significant Values**	**Conclusion**
1(a)	H_0: There is no significant difference between the variables with load X and age	0.089	Accept H_0
1(b)	H_0: There is no significant difference between the variables with load Y and age	0.275	Accept H_0
2(a)	H_0: There is no significant difference between the variables without load X and age	0.181	Accept H_0
2(b)	H_0: There is no significant difference between the variables without load Y and age	0.275	Accept H_0
3(a)	H_0: There is no significant difference between the variables free position X and age	0.498	Accept H_0
3(b)	H_1: There is a significant difference between the variables free position Y and age	0.006	Reject H_0
4(a)	H_0: There is no significant difference between the variables stretch position X and age	0.169	Accept H_0
4(b)	H_0: There is no significant difference between the variables stretch position Y and age	0.290	Accept H_0

Duncan test divides the entire data into two or three homogeneous groups. Identical groups or subsets are placed at one place and different groups or subsets are placed at another place. The graph shown below is based on Duncan test.

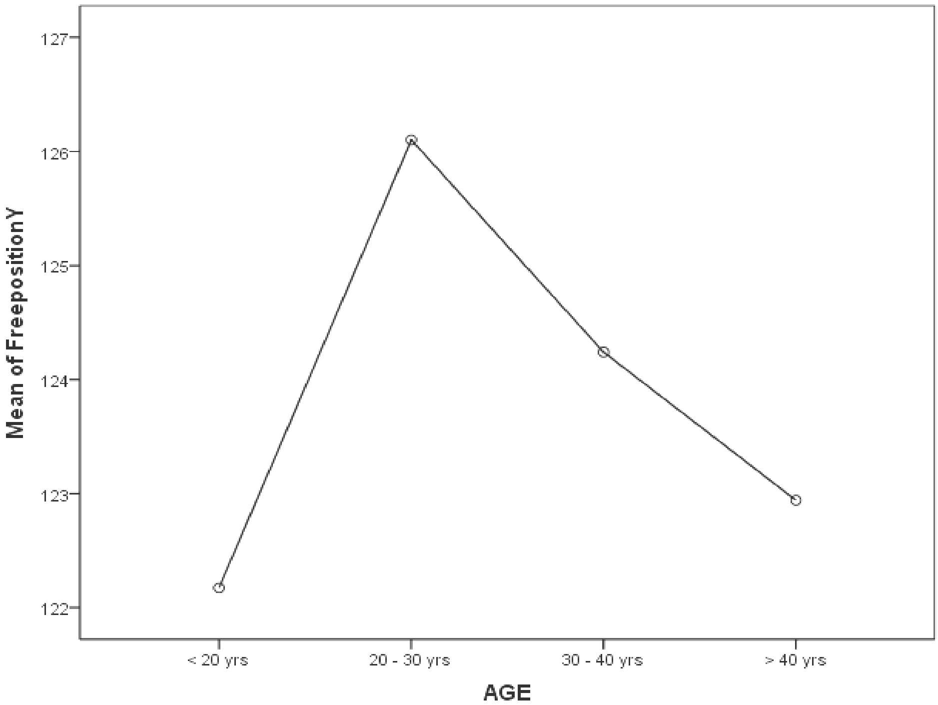

Fig. 5. Graphical representation of age on X-axis and variances of free position along Y-axis based on Duncan test.

IV. CONCLUSIONS

This device is a low cost, highly portable device and can be used for remote applications and also in order to detect tremors for tele-medicine purpose. This work helps the doctors to monitor patients who are in Coma, as mild movements in the body can be detected and sent on the doctors PC. It helps the doctors to identify how a patient is responding to the treatment. The device is designed in such a way that the sensor used to identify tremors have very small signal to noise ratio. The size of MEMs sensor is compact and its performance is good. So this work is basically used where tremors are to be monitored, recorded and analyzed for the treatment of patients. It is found that there is an impact on patients of different age groups .A few relations that take into consideration X and Y movements were identified, which helps in detecting tremors and measuring their intensity.

A further improvement in this work can be done to increase the speed of data transfer by using USB port instead of RS232 connected between PC and microcontroller and obtaining the frequency of deviation along the control group and effected group using signal processing.

V. ACKNOWLEDGEMENTS

The authors are thankful to the Saibaba charitable trust Hospital, Malkajgiri-Secunderabad and also to our esteemed professor Dr. Y. Narsimha Murthy, to carry out the research work with his valuable suggestions.

REFERENCES

[1] Y. Dileep Kumar and A. M.Prasad, “Mems Accelerometer System for Tremor Analysis,” International Journal of Advanced Engineering and Global Technology Vol-2, Issue-5, ISSN No: 2309-4893, May 2014.

[2] A. Michalski, and A. Chwaleba, **“**Mathematical approach to tremor recognition in extrapyramidal disease,**”** Instrumentation & Measurement Magazine, IEEE (Volume:6, Issue:1) **ISSN:** 1094-6969 Mar.2003.

[3] S. P. N Singh, and C. N. Riviere, "Physiological Tremor Amplitude during Retinal Micro Surgery," Bioengineering Conference 2002, Proceedings of the IEEE 28th Annual Northeast, Philadelphia, pp. 171-172, August 2002.

[4] G. C. Higgins, and K. F. Stutlz, "Frequency and Amplitude of Ocular Tremor," Journal of Optical Society of America, vol. 43, no. 12, pp. 1136-1140, 1953.

[5] M. U. Humayun, R. S. Rader, D. J. Pieramici, C. C. Awh, and E. de Juan, Jr., "Quantitative Measurement of the Effects of Caffeine and Propranolol on Surgeon Hand Tremor," Arch. Opthalmol., vol. 115, pp. 371- 374, March 1997.

[6] M. J. Elman, J. Sugar, R. Fiscella, T. A. Deutsch, J. Noth, M. Nyberg, K. Packo, and R. J. Anderson, "The Effect of Propranolol versus Placebo on Resident Surgical Performance," Trans. Amer. Opthalmol. Soc., vol.96, pp. 283-291, 1998.

[7] R. H. Taylor, P. S. Jensen, L. L. Whitcomb, A. Barnes, R. Kumar, and D. Stoianovici, "A Steady-hand Robotic System for microsurgical Augmentation," The International Journal of Robotics Research, vol. 18, no. 12, pp. 1201-1210, December 1999.

[8] B. Mitchell, J. Koo, I. Iordachita, P. Kazanzides, A. Kapoor, and J. Handa, "Development and Application of a New Steady-hand Manipulator for Retinal Surgery," IEEE Conference on Robotics and Automation, Rome, Italy, pp. 623-629, April 2007.

AUTHORS

Dr. I.V. Subba Reddy was born in India in 1975.He Completed his B. Sc., M. Sc., and Ph. D. Currently he is working as Associate Professor in Department of Physics, GITAM University Hyderabad. Dr. Reddy received several national level fellowships and got the prestigious Marie-Curie fellowship for Post Doctoral Researcher/Adjunct Professor in the year 2008 from the University of Lodz, Poland. Research Scientist/Visiting Professor in the year 2007 at Kyoto University, Japan and Post Doctoral Researcher in the year 2005 from National Central University, Taiwan. He received Chanakya Award under most promising Young Visionary category and is a National Award given by Public Relations Council of India (PRCI) in 2013.

Bhamidi Rama has completed B.Sc, M.Sc App. Electronics and M.Phil Electronics degrees. Currently she is working as Head of the Dept. of Electronics Technology at Loyola Academy degree & PG College .She has a wide teaching experience since 1995. Worked as Controller of Exams for the academic year 2010-2012 at Loyola Academy Degree and PG College. She is receiving the best department award from management for past 6 years. Coordinator for certificate courses sponsored by UGC. As a chair person for Board of Studies she played a key role in enhancing the syllabus according to the industrial needs. Her BRAIN CHILD is LAB TO SCHOOL program, where practical's of physics and chemistry of 9th &10th class are taken to prepare models. These are done under her guidance by degree students and are displayed at government schools. Her research areas are Microcontroller based systems and