

Low Cost Portable Physiotherapy Machine with Passive Harmon Graph Programming Setup

Dadi Ravikanth¹, Hariharan. P²
 Department of Manufacturing Engineering,
 College of Engineering Guindy,
 Anna University, Chennai, India.

Abstract— Neural disorder is one of the most rapidly affecting syndrome in present day. Disorder through neural stimuli leads in loss of movements in motor units, shut down of sensory cells, and other internal neuron-skeletal changes occur. The problem statement is, how can we face the problem in growing busy life? In this paper, a new passive motion transfer using Harmonograph curves and its relation to existing technology transformation in clinical therapy has been discussed. Haptics and quantum touches from ancient practices and its relation with passive dynamics in modern technology can explain many realistic experiments behind clinical research.

Keywords:- Neural disorder, Physiotherapy, Haptics, Augmented Reality, Harmonograph.

I. INTRODUCTION

Human's with science has always been remarkable in understanding and protecting his own beings from endangering. Twentieth century gave birth to new industrial and modernisation era for human life style, thus leaving his brain work for hours together. But when human's cross the resistance value specified by nature, then brain seeks massive amounts of energy by shutting down few senses without intimation for its survival. This shut down might sometime leads to neural responses breakdown experiencing changes in Central Nervous System(CNS), Peripheral Nervous System(PNS), Musculo-Skeletal Systems, and other minor responses related to motor functions[9][10].

Process of stress over continuous time period leads in changes in genetic memory which directly changes the physical expression of future generations. For example: we have never seen or heard of animals taking birth with physical disabilities or generating any post birth irregularities (except cross breeding)[1]. This explains us how nature helps when we walk parallelly with it whereas Brain has eventually evolved because we started protecting ourselves with various medication procedures. We have also changed the growth of Neural-Skeletal-Muscular diseases they all are increasing with increasing in brain size. Stress in genetic memory plays a vital role for future observation, so why should we spoil our genetics and disturb future generation. Altogether 29 neural disorders have been observed since 1925[3]. Out of which 60% of neural disorders are genetic and 40% are adoptive from our lifestyle pattern called stress[5].

Human might have explored technology for survival but still he is in search of satisfaction and relaxation. In this paper we will be discussing and explaining about various human disorders, psychological stress, and importance of sense of

touch in human physical to mental relations. Thus finally discussing about physiotherapy for human health care and design analysis of the machine for generating random patterns.

II. PHYSICAL THERAPY AND NEUROPSYCHOLOGICAL REHABILITATION

Since 4500BC in countries like India, China, Japan and Greece, physical therapy was considered as a major knowledge of medicine. In India it's considered as religious and spiritual way to follow physical therapy both assisted and self-aligned. This is termed as Ayurveda, which specifically says "life wisdom". Similar patterns were also seen in Japanese culture termed as "Shiatsu", which also explains how individual organs function with response to central nervous system[2][8].

In modern era physical therapy was adopted as a profession in 1914 to 1920 with the raise of western industrialisation. Stress over man made him adopt the ancient techniques with modern ethics, by forming society of physical therapy after World War 2. Physical therapy mainly classified as Therapeutic Massage, Hydrotherapy and Therapeutic Exercise. Therapeutic massage is a process which is alleviated over triggered points over human body through periodic cycles. Hydrotherapy involves triggering pain stimulus with help of water/fluid. Therapeutic exercise deals in physical movements of human body over certain procedures. After World War 2 therapist round the world have aimed in maximizing the patient functions, alleviating the pain, decreasing abnormal stress, motion and flexibility.

In human body adaptation of disorders though stress take place inside central nervous system which slowly spread to peripheral nervous system creating a failure in information transfer between motor unit and spinal cord to brainstem. The disability of information from CNS leads to inactive motor neural motion and hence losing physical actions. The motor unit is an important part in human movements which controls musculoskeletal movements. The structural format still remains as an hypothetical but neuroscience defines that motor neurons existing at sensitive parts like face and palm has 1 motor neuron unit for 4 muscle fibre to control precision movements, whereas for remaining part of human body 1 motor neuron unit for 2000 muscle fibre[4][11]. Due to this ratio between active precision muscle fibre and low precision muscle fibre human hands and legs get effected to neural disorder if physical actions aren't performed. The number of effected motor neuron unit is totally depended

upon the magnitude value of activated muscle fibre over the response to a given stimulus[12][13].

Physical therapy based on the parameters and magnitude factor of effected muscle fibre is usually taken from shape and structure of muscle. Structures of muscle that protects skeletal and neural motor unit are usually like circular, multi-pennate, parallel strap, uni-pennate, bi-pennate, parallel fusi form and convergent structures. Existing physiotherapy uses these natural shapes and have designed various types of machines for processing over effected part. Taking from Indian ancient pattern of physiotherapy which uses only hands and fingers for healing over triggered point. Which states that sense of touch is necessary in physiotherapy machines which deals with more of “Insult with brain” and emotions triggered sensory system of peripheral neuron system. Whereas, existing portable physiotherapy/ physical therapy machines are vibration assisted, but vibration frequency from 10Hz to 24Hz is human sensitive and over continuous time these vibrations leave skin disorders leading to ageing effect of skin[6].

Ancient practices involved in touching and developing a pattern over triggered area, enhancing the sensory system to provide sufficient signals to thalamus by increasing in blood circulation[7]. To obtain human sense of touch through machine in present generation is termed as Haptics technology. Haptics is sense of touch that humans have pursued in evolution in form of skin which can feel pain,

heat, cold etc., also by achieving kinaesthetic motion through muscles. Philosophy of human sense of touch involves in concepts like love and affection and our brain always love the concept of touch so in evolution we always pursue a partner to acquire a peaceful life. And unexpected touch movements create a massive difference from expected touch, brain triggers heavy amount of sensory neurons signals to entire body for unexpected permutation. The low cost concept physiotherapy machine involves in such a touch felt by human with unexpected therapeutic massages pattern generated by Harmonograph equations.

III. MODELLING AND UNDERSTANDING EXPERIMENTAL SETUP OF HARMONOGRAPH

Harmonograph, with name it state that this is related to sounds and harmonic progressions in wave theory. Harmonograph is a machine that was built by a mathematician, Professor. Blackburn in 1844 in order to study sounds. Instrument made up of 2 or more pendulums assembled with a design ethics to draw beautiful pattern of 3D curves over a fixed frequency limits and exerted within limited amplitude ratio. These instruments have pendulums which are damping in nature and hence obtain an angular frequency for oscillations over time interval which certainly decays with rate proportional to damping constant.

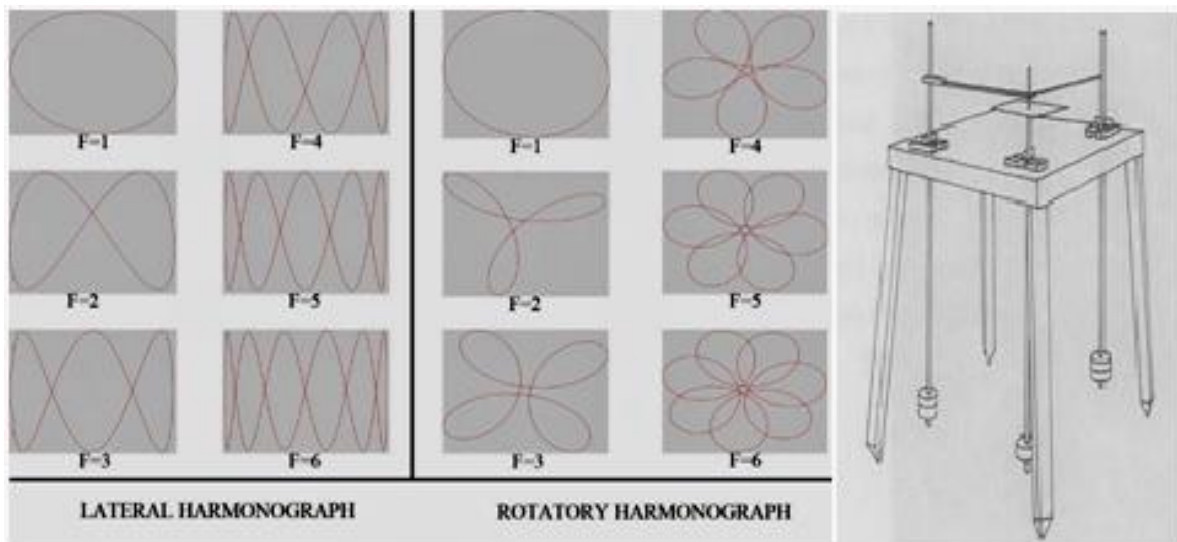


Fig. 1. 1844 Professor. Blackburn's diagram of Harmonograph and Lateral & Harmonograph curves with single cycle over multiple loops. (F = Frequency)

Harmonograph machines vary with the design they are classified into various types based on the pattern of curves they generate. Lateral and Rotatory are the two basic Harmonograph orientations which are operated based on division of frequency levels. Lateral Harmonograph is again characterised as open phase and closed phase by changing phase angle from -180° to 180° respectively. Based on similar principle of dividing frequency cycles and phase Rotatory Harmonograph is also classified into two types, Concurrent and Counter Concurrent. Breaking the frequency ratio will give overlapping of the curves and assuming maximum overlap in one loop to be 8 for the following

experiment. Curves shown in Fig. 1. Are all taken based on configuration of Harmonograph, but usually taken from pendulum under damping condition. Normal pendulum is freely moving and in theoretical pattern we never consider the damping and decay rate. While in practical orientation we need to specifically generate pendulum under damping conditions with variation in amplitude and frequency.

Generalised equation for pendulum under damping condition is given as:

$$X(T) = A \sin(TF + \phi) e^{-DT} \quad (1)$$

'A' is amplitude of the curve.

'T' is the time taken to complete one loop.

'F' is the frequency of the curve which defines number of overlapping in one loop.

'Ø' is the Phase of the loop (ranges from -180° to 180°).

'D' is the damping constant of the pendulum.

Assuming these parameters we define the path of damped pendulum which follows single axis law. Coming to multiple axis in Harmonograph, lateral Harmonograph and rotatory Harmonograph machines define curves based on Eq.1. But for 2 axis pendulum or 2 axis with multiple pendulums equations needs to be extended.

$$X(T) = A_1 \sin(TF_1 + \phi_1) e^{-D_1 T} + A_2 \sin(TF_2 + \phi_2) e^{-D_2 T} \quad (2)$$

In Eq.2. It is defined for 2 axis pendulum where one pendulum is acting pendulum and second pendulum is established under base plate which itself moves. With notations coming from 2 pendulums we can assume that entire system is having constant frequency and generating uniform curves. And by substituting $F_1 = F_2$, similar damping constant.

$$X(T) = A_1 \sin(TF_1 + \phi_1) e^{-D_1 T} + A_2 \sin(TF_1 + \phi_2) e^{-D_1 T} \quad (3)$$

Generally in pendulum angle of elevation over the potential energy is considered to be the summation of

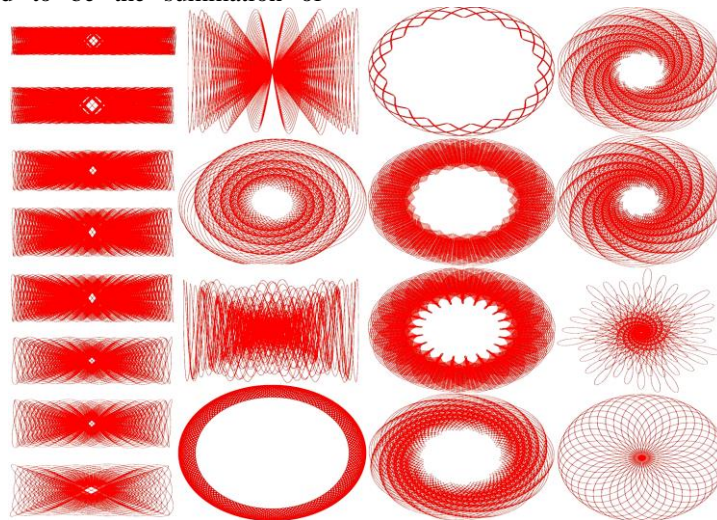


Fig. 2. Computer Generated Curves based on Equation of Damping 2 Axis Pendulum

IV. DESIGN OF PHYSICAL THERAPY DEVICE

A portable device is always small in size and maintains the rhythm irrespective to its dimension. Our idea was to develop a portable size light weight device that will give continuous variations in curves and surprise the user with Haptics integrated therapeutic massage. According to ancient Indian practices is to cure any physical therapy through human sense of touch. As the properties of Harmonograph we saw in Eq.4. Generates 40320 curves from 8 loops in one frequency generated under random amplitude factor.

A small portable box which has an integrated Harmonograph and the pendulum inside the Harmonograph is operated with solenoid providing magnetic pull and the

Elevation angle to normal angle. So $\phi_2 = \phi_1 + 90^\circ$; when assumed to be operating in similar frequency. And amplitude of both pendulums on curve is defined to its ratio i.e.

$$A = A_2 / A_1$$

substituting in Eq.3. And A_1 from over common can be eliminated because of overall ratio of the amplitudes.

$$X(T) = A_1 \{ \sin(TF_1 + \phi_1) + \left(\frac{A_2}{A_1}\right) \sin(TF_1 + (\phi_1 + 90^\circ)) \} e^{-DT}$$

$$X(T) = \{ \sin(TF_1 + \phi_1) + A \sin(TF_1 + (\phi_1 + 90^\circ)) \} e^{-DT} \quad (4)$$

Based on Eq.4. And varying values (F, Ø₁, D, A) within function by generating various patterns of curves and changing the orientation in frequency loops can be defined. Whereas by defining time at exponential will generate gradual decay of the loops by making overall loop time to be constant.

The pattern obtained can be used in therapeutic massages. Concentration obtained from frequency to amplitude can create 8 overlapping in one loop creating 8! Iteration in identifying the pattern. 8! Is generated in single axis alignment where as in 2 axis we get 16! Oriented curves. Every curve is controlled with time which defines number of loops to be generated.

amount of magnetic pull will generate amplitude of the curve. In 2 axis Harmonograph we have even base pendulum to govern itself through solenoids. This second axis pendulum provides frequency of operation and once initiated will not stop for certain time. Undetermined process of generating patterns is generally termed as passive programming. This procedure also has limitations in exciting pendulum bob when all solenoids are high or alternative solenoids are high then movement of bob is meant to be in static condition. But by varying the pattern with differential magnetic flux will reduce the problem and also reduce the complexity of understanding human error. Tip of the Harmonograph where actual curves are taken is fixed with an accelerometer which transfers axis co-ordinates to therapeutic massage.

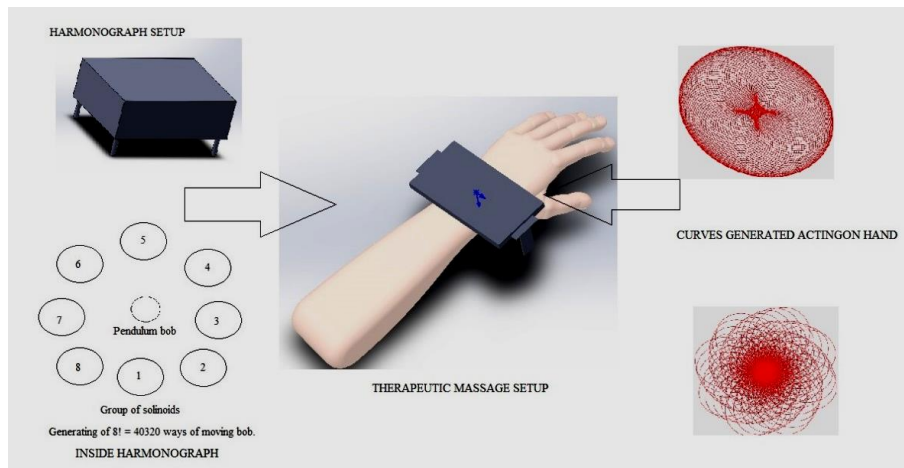


Fig. 3. Design setup of portable Harmonograph machine and therapeutic setup for visual understanding of reader.

As shown in Fig. 3. motion generated inside Harmonograph machine is transferred to the therapeutic massager which holds a human dexterous hand setup made from pneumatic and silicon to give real feel of human touch. The dark circles generated with concentration is the centre of the curve which while decaying leaves maximum concentration and by changing the phase of the Harmonograph machine one can place the concentrated centre at trigger point. As compared to neurological disorder it is heavily concentrated for longer time period making motor units and other peripheral neurons to become inactive, whereas in Harmonograph curves it generates a concentrated centre helping a user feel better than usual pattern of human trained massage. Referring the idea on larger scale of human body setup can be designed to control massage through Electro Muscle Simulation. In this techniques we will be trying to use electromagnetic resonance to generate impulse in muscle for activating or re energizing motor neurons. An additional parallel manipulation will also play a synchronizing role in providing kinesthetic motion.

V. DISCUSSION AND CONCLUSION

Curves generated can help in stimulus to trigger the dead motor units, regenerate cardiac movements and help in betterment of musculoskeletal disorders. In physical therapy maximum of times patient loses insult over brain, which leads in distress and emotional effects. In near future this portable device will be integrated with pure haptic sense of touch. Being installed with mechanical components this portable device cost less and harmonic programming gives unexpected therapy pattern. Curves can be integrated with any existing therapeutic technique by adding another degree of freedom. Intelligence of a device or a machine is defined with the randomness behaviour embedded within the actuation. Harmonograph curves on machine can use concepts like "Discrete Event" to avoid repeatability of random number in path generation. Thus helping existing technology to get upgraded with low cost on public domain. Infact few scientist believe that randomness is part of human evolution, so approaches like vibration massage, kinesthetic approaches and other clinical approaches will have better output over human brain. So looking at the future research a robotic

Harmonograph programming setup should be the target towards the cure of neurological disorders and Neuro Muscular disorders.

REFERENCES

- [1] Wilson, B.A. "A Survey of Behavioral Treatments Carried out at a Rehabilitation centre", Brain Function Therapy edited by G. Powell, 1981, pp. 256-275.
- [2] John Douillard, (2004) "The Encyclopedia of Ayurveda Massages". North Atlantic Books, 2004.
- [3] Olga Dreesen (2011). "Introduction to Physical Therapy for Physical Therapist Assistants 2nd edition". James and Bartlett Learning LLC, 2011.
- [4] MacDonald. F.A. "Mechanics of Movement", G. Bell London, 1973.
- [5] Sandy Frilz. "Massage Therapy Review 3rd edition", Mosby Elsevier, Canada, 2013.
- [6] William G.Boissonnault, "Primary Care for the Physical Therapist". Elsevier Saunders, USA, 2011
- [7] Kim Jomes, Karen Barker, "Human Movements Explained". Physiotherapy Practice Explained Series. Professional Publishing Ltd, 1996.
- [8] Yuichi Kawad, Stephen Karcher, "Essential Shiatsu", Japanese Art of Healing Personal Health and Spiritual Well Beings. Time Warner Books. Great Britain, 2002.
- [9] Sheila Leannon, Maria Stokes, "Pocket Book of Neurological Physiotherapy", Churchill Livingstone-Elsevier, 2009.
- [10] Palastanga.N et. al, "Anatomy and Human Movements 2nd Edition". Structure of Muscle. Butterworth-Heinemann Oxford, 1994.
- [11] John Skarkey, "The concise Book of Neuromuscular therapy". Lotus Publications. California, 2008.
- [12] Robert J. Whitaker, "Harmonograph II Circular Design", American Association of Physics Teachers, 2001.
- [13] Barbara A.Wilson et al, "Neuropsychological Rehabilitation" Cambridge university press, New York, 2009.