Capsulization of Tremor Suppression by Using Various Techniques

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Abstract – Remote manually operated tasks such as those found in teleportation, virtual reality, or joystick based computer access, requires the generation of an intermediate electrical signal which is transmitted to the control subsystem. Tremor affects the human movement which can be improved by using various techniques. One of the popular tremor compensation method is based on weighted frequency Fourier linear combiner (WFLC) algorithm, which changes frequency as well as amplitude of tremor signal. This paper provides development and initial experimental result of first prototype of micron system and gives the comparatively study of FLC & WFLC.

Keywords – Tremor, micro system, FLC, WFLC.

I. INTRODUCTION

Tremor is characterized by involuntary oscillations of a part of the body. The most accepted definition is as follows: “an involuntary, approximately rhythmic, and roughly sinusoidal movement” [2]. Tremor is the most common movement disorder and is a major source of functional disability, affecting many of the daily living tasks.

Classification, Categories into four types
- Rest
- Postural
- Kinetic
- Task-specific.

Rest tremor is typically observed in Parkinson’s disease [1]. Tremor occurs when the affected part of the body is in repose and fully supported against gravity, requiring no voluntary contraction.

Postural tremor occurs when the subject attempts to maintain a posture, such as maintaining the upper limbs outstretched. The following conditions are associated with postural tremor: physiological tremor, essential tremor, cerebellar tremor, post-traumatic tremor, peripheral neuropathy.

Kinetic tremor occurs during purposeful movement; for example, during finger-to-nose test (the patient is asked to put the index finger on the nose). Kinetic tremor is highly suggestive of a cerebellar disorder (cerebellar ataxia) or a disease involving cerebellar pathways. Midbrain tremor combines rest, postural, and kinetic tremor.

II. ARCHITECTURE OF MICRON SYSTEM

The intelligent active vitreoretinal microsurgical instrument is known as ‘Micron’ as shown in fig. 1 [2], [3], which measures 75 to 150 mm long and 10 to 15 mm in diameter, with an intraocular shaft roughly 30 mm long and 1 mm in diameter. The first prototype weights 170 g and is 210 mm in length (including the 30 mm intraocular shaft) and has an average diameter of 22 mm [2]. The handle is contoured near the tips as an aid to grasping.

Architecture of the complete micron system is as shown in fig. 2 [3]. The current system controls the piezoelectric actuators in open loop. In the future, strain gauges will be added to sense the deflection of the actuators in order to provide closed-loop control as indicated by dotted arrows in fig. 2.
III. METHODS OF TREMER SUPPRESSION

The most relevant technique for tremor suppression are as follows

A) Adaptive Tremor Cancelling

An adaptive noise canceller is a noise filter that self optimizes on-line as it encounters an input signal, adjusting its parameters according to a learning algorithm[5]. The block diagram of the adaptive noise canceller is drawn in fig. 3.

The system contains of two inputs one is primary (S_k) and other is reference input (X_k). primary input S_k[8], containing a desired signal d_k and uncorrelated noise n_k; and a reference input X_k, containing noise correlated n' with correlated n_k. The reference input is processed by an adaptive filter that automatically adjusts its own impulse response through LMS that responds to an error signal dependent on the filter’s output.

![Fig. 3 Adaptive Tremor Cancelling](image)

This adaptive noise canceling scheme requires a reference signal. In many human-machine control applications, obtaining a reference signal that contains tremor is not convenient [8]. However, there are a number of ways to resolve this difficulty. For periodic interference, one such method is to generate a reference input via a tapped delay line that receives the primary input, delayed by some amount. This adaptive filter structure therefore attempts a linear prediction of the current noise value based on past value, and is known as an adaptive predictor [9]. Implementing this type of filter for tremor canceling in control applications is problematic for two reasons. Little is known about the human voluntary motion so it is difficult to determine a suitable value for the tapped delay. A more significant drawback is that the system models the interference as a linear autoregressive process. Since pathological tremors are non-linear process, the linear prediction is therefore unlikely to yield a satisfactory estimate of the tremor, particularly when delayed by a potentially large value.

B) Fourier Linear Combiner (FLC)

The Fourier Linear Combiner (FLC) estimate the Quasiperiodic signal of known frequency by adapting the amplitude and phase of an oscillation in the primary input and tracks their changes[9]. It is computationally inexpensive, inherently zero-phase, and has an infinite null. For M=1, the algorithm can be viewed as an adaptive notch filter, the width of the notch created at ω_0 being directly proportional to [15]. However, cancellation of periodic interference with the FLC depends on determination of the proper reference frequency, ω_0. The FLC cannot estimate the proper ω_0 value on-line because the tremor frequency is not known a priori. Fig 4 shows the FLC. Making the FLC useful for tremor cancelling during human-machine control requires a method to adapt the reference frequency to the primary input frequency.

![Fig. 4. Fourier Linear Combiner](image)

C) Weighted Frequency Fourier Linear Combiner (WFLC)

Due to the non-stationary nature of tremor, effective canceling requires adapting to change in both frequency and amplitude, whereas the FLC [1] operates at a preset fixed frequency. To provide the needed versatility, the FLC has been extended to the case of time-varying frequency in the weighted-frequency Fourier linear combiner (WFLC) [8], shown in Fig.5.

![Fig. 5. Weighted Frequency Fourier Linear Combiner](image)

Riviere and Thakor modified FLC by replacing the fixed frequency, ω_0, of the FLC with another adaptive weight, kω_0, that learns the input frequency via the LMS algorithm, much as the FLC weights learn the input amplitudes [15]. Like the FLC, the WFLC forms a dynamic truncated Fourier series model of the input. Unlike the FLC, the WFLC [8], [14] adapts the frequency of the model as well as its Fourier
coefficients to match the input signal. Fig.6 shows WFLC. The WFLC is, therefore, well suited to compensating for approximately periodic disturbances of unknown frequency and amplitude. The WFLC [15] algorithm is used to model the pathological tremor as a modulated sine wave to model the pathological tremor [9] as a modulated sine wave with a time-varying frequency and amplitude. At every time step, error is measured between the tremor signal and the reference sine wave; depending on the error, frequency and amplitude of the reference sine-wave are adjusted.

IV. COMPARISON OF VARIOUS TECHNIQUES

<table>
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<tr>
<th>S.No.</th>
<th>FLC</th>
<th>WFLC</th>
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<tr>
<td>1</td>
<td>Does not adapt frequency model.</td>
<td>Adapt frequency model.</td>
</tr>
<tr>
<td>2</td>
<td>Fourier coefficient doesn’t match to input signal.</td>
<td>Fourier coefficient match to input signal.</td>
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V. PROBLEM DEFINITION

The tremor minimization is very important during laparoscopic surgery. The FLC technique is used but it has some disadvantage. To overcome this drawback we use WFLC technique.

VI. CONCLUSION

Implementation of WFLC technique is helpful to minimize the tremor in laparoscopic as well as enhance the accuracy.

REFERENCES


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