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NEW IMAGE-BASED SYSTEM FOR VIBRATION MEASURMENT, SPECIALLY DEVELOPED FOR FORCED HUMAN VIBRATION ANALYSIS

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ABSTRACT

The human being in the environments of modern technology has to endure stresses of many and varied kinds of vibrations [1]. Measuring vibration is an important tool in rehabilitation and biomechanical fields of research. We have proposed image processing as a new method to record and determine the frequency response of human body. The subjects were exposed to whole body periodical vibration while standing on a shaking table. Two digital camcorders were used to capture the motion of colored pencil-dot markers on the skin of human body (forehead) and on the edge of the shaking table. After color spotting each frame, the binary image results were processed using new circle factor criteria proposed in this work, for fast finding circles based on second order statistics. The extracted points were calibrated using our own extended version of the direct linear transformation (DLT) method. We subsequently used Borland Delphi 5.0 language to develop useful software for measuring and analyzing human body vibration. As a result, it was clear that the proposed method was lower noise-sensitive in comparison to accelerometer. In order to investigate the validity of the software, the obtained mechanical impedance of the body were compared with other investigations in literature and showed to be compatible. The main advantage of this method is working with a simple user-familiar hardware with no external device attached to the subject and also a user-friendly-software.

METHODS

The arranged set-up for producing the whole body vibration consisted of an ISGEV 380 V, AC electromotor, a variable speed drive unit and a shaking table. A screw on the base plate of the shaking table was chosen as the reference marker and a white spot painted on the forehead of the subject was taken as another marker. The images of the motion of these two markers were taken by two digital cameras (Sony DCR-TRU-330EE15) from distance of 60 cm with 200X zoom ratio and speed of 25 fps. The size of captured images were about 1x1cmirst Image processing was carried out step by step. The colored image first was analyzed to find the standard intensity. Using the well-known double-margin threshold function it was thresholded next, then a recursive fill-flood style operation were used to labeling the region of the markers and five parameters of S , S_x , S_y , S_{x^2} and S_{y^2} , as shown in equation (1), were computed consequently [2]. Where A is: The area including all the points, S : The number of points, S_x : Sum of the x components of points, S_y : Sum of the y components of points, S_{x^2} : Sum of the x^2 components of points, S_{y^2} : Sum of the y^2 components of points, μ_x : Mass center point in x direction, μ_y : Mass center point in y direction, γ_x : Standard deviation of points in x direction, γ_y : Standard deviation of points in y direction and λ is the deviation from circular shape. The point (μ_x, μ_y) in equation (1) was the center of region, and λ was its circularity. For a fine circle, λ was equal to one while larger values of λ showed more deviation. Using a simple threshold on $\lambda(\lambda \leq 1+\varepsilon)$, circles was classified. It must be considered that the criterion λ is a newly derived expression by the authors.

$$\begin{cases} A = S \\ \gamma_x = \sqrt{\frac{S_{x^2}}{S} - \frac{(S_x)^2}{S^2}}, \gamma_y = \sqrt{\frac{S_{y^2}}{S} - \frac{(S_y)^2}{S^2}} \\ \mu_x = \frac{S_x}{S}, \mu_y = \frac{S_y}{S} \\ \begin{cases} \lambda = \frac{\pi(\gamma_x + \gamma_y)^2}{A} \\ 1 \leq \lambda < \infty \end{cases} \end{cases} \quad (1)$$

To eliminate small circular noise regions the methods used either of the parameters $\sqrt{\frac{A}{\pi}}$ or $\gamma_x + \gamma_y$ as the radius of the region. Then putting the threshold on the radius while the threshold on circularity was applied before, the true marker was classified at the point (μ_x, μ_y).

RESULTS AND DISSCUSSION

Many methods for de-interlacing the image are reported in literatures [3]. We adopted the fast method of low-pass filtering the frames prior to the operation, for the sake of performance to solve the distortion of the marker placements. We used the mass-center of the marker images, adding a filtering stage to the output data inevitably. The proposed method for bypassing the windows event-queue results in a much higher performance, making the method applicable for real-time uses. The shape of e marker is not very important, compensated by prefer selection of the parameters. The markers must be selected in the way that their dimensions are less than half of the vibration amplitude, furthermore they must be easily distinguishable from the vicinity, and care must be taken that the markers do not cross the image borders at any time.

As an example of mechanical analysis by the software, markers' data were used to obtain the mechanical impedance of a subject which has been illustrated in figure 1 (Solid line). Furthermore it has been shown to be in the same range comparing with other investigations in the literatures [4]. The results from accelerometer method [5], however shows significant differences due to tissue-accelerometer vibration.

CONCLUSION

The developed system is an applicable alternative for an accelerometer system. Hardware prices are much lower in this

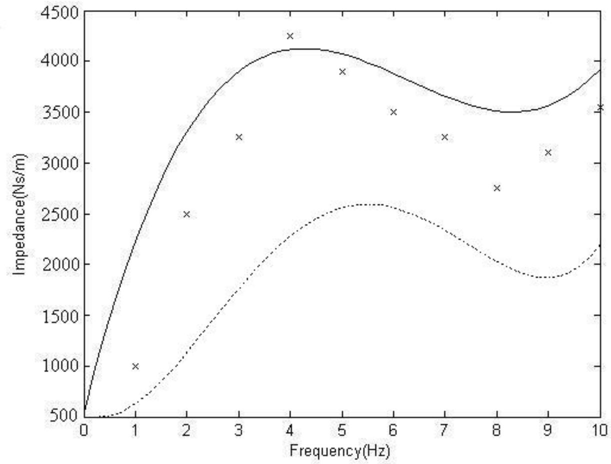

Figure 1. The whole body mechanical impedance for vertical direction. Result found in this study for a sample subject $(-)$; Holmlund et al. $(\times)$ [4]; Accelerometer data (…) [5].

System and noise sensitivity is dampened, however the processing time is longer (average 2.5 times more). The designed system uses general-purpose hardware but more sophisticated software. Though the purpose of this study is introducing and devising a new method for measuring human body vibration, with a sufficiently enough number of subjects an extended amount of impedance and transmissibility data would enhance our possibilities to a better understanding the causal connections with respect to health, annoyance and performance.

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