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Using personal computer to measure vertical deviation from a prescribed horizontal track

استخدام الحاسوب لقياس الميلان العمودي لحركة اليد بدلالة زمن الحركة وعمر الشخص

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الخلاصة:

تتناول هذه الدراسة مدى ميلان اليد عن اتجاه حركتها الأفقي، حيث تبين ان هذا الميلان الذي يعتبر نوع من الحركة الغير مقصودة يعتمد على زمن الحركة وعمر الشخص، كما تبين ايضا ان زمن الحركة يعتمد على العمر. حيث استخدم القلم الضوئي في تحصيل الأشارات.

اظهرت الفئات العمرية لصغار السن وكذلك كبار السن ان نسبة الميلان عالية بينما كانت النسبة اقل من ذلك بكثير للاشخاص متوسطي السن. هذا وقد دلت التحليلات الأحصائية على ان معامل الأرتباط بين الميلان وزمن الحركة لجميع الأشخاص يفوق نسبة 86%، بينما كانت النسبة بين الميلان والعمر عند صغار السن >0.96- وكانت < 0.96 عند كبار السن. اما فيما يتعلق بمعامل الأرتباط بين زمن الحركة والعمر عند صغار السن فهي > 0.99- بينما كانت > 0.98 عند كبار السن.

Abstract:

This paper aims at measuring the vertical deviation of the hand while conducting a horizontal movement, in an attempt to show the relationship between deviation and age, and deviation and movement duration. This necessitates the investigation of hand movements of subjects with varying ages. A light pen is used for capturing the signal induced by the hand movements. Deviation is found to be dependent on duration and age of subject. Young and old aged subjects show large deviation in contrast to middle-aged subjects. Correlation factor for deviation and duration is equal to 0.86 for all subjects.

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Correlation factor for deviation and age is > -0.96 for young subjects and is > 0.96 for old subjects.

Correlation factor for duration and age is > -0.99 for young subjects and is > 0.98 for old subjects. Two mathematical formulas are presented; the first expresses the dependence of deviation on age while the other expresses the dependence of duration on age.

I - Introduction

Shipley, in 1995, measured two dimensional hand movements which lead to a sound understanding of nervous system. Tony et al in 2001 used Microprocessors and Microcomputers to capture and analyze human biomedical signals in speedy and concise terms.

Muheilan, in 1999 captured and analyzed human medical signals associated with eye movement in real time. This type of work is essentially needed as a diagnostic tool for assessing human health, which is also supported by the work done by (Marcus, 2001).

Upper limbs movement such as the hand is analyzed in a previous work done by the author in terms of the horizontal motion (Muheilan 2003) and is found to be affected by the age of the subject undergoing the test, movement disorders are found useful in the diagnoses of hand disability (Jackson, 1980) and where it can lead to better understanding of the nervous system control (Alan, 1997). These findings have affected the practice of clinical neurology and produced new diagnostic techniques for hitherto untreatable conditions (Andrew, et al, 1997).

Based on previous results this research postulates that horizontal hand movement deviation thought of as an error signal is affected by certain parameters considered in this work, such as the age of the control and the time of the hand movement. Therefore; the one-dimensional movement previously investigated will be considered again but from a different prospective, where the effective deviation produced while holding and moving an object such as a light pen was determined by the connected personal computer.

The deviation of the movement will be considered as a function of:

1- Time elapsed during the motion.

2- Age of the control undertaking the test, based on horizontal one dimension tracking.

Movements were captured through different techniques using transducers tightened to the part of the body under consideration (Polla, D. et al 2000). But these methods were found troublesome and hazardous in terms of the leakage current that might be injected into the body unintentionally (Leigh, R. and Zee, S. 1983). The authors proposed another method that proved to be simple and safe; therefore it will be used again in this work as will be explained in the methodology ahead.

Cleary, et al, in 2002, reported that hand movement disorders may be associated with the use of computers accessories. In this work, however, this approach will be tested for the validation, where a light pen will be used to capture the signal, and a supporting software programs (given in Appendix1) will realize the process of capturing, analyzing and presenting the signal in the time domain using Visual Basic 6 (Deitel, h. 1999).

Analysis of one-dimensional motion using this technique is still preferred particularly the measurement of deviation from a prescribed trace as a function of time and age.

II - Methodology

The light pen is a peripheral device that can be interfaced to the personal computer, its sampling time is 20μs, data is captured at a rate of 20ms using the software prepared, as the light pen transmits and receives a self induced pulses at a prescribed frequency of 50kHz, contamination of the signal with the 50Hz mains frequency and others sources of noise are eliminated.

This work made use of this fact, whereby the subject is instructed to hold the light pen as if it were a normal pen and to move the hand horizontally in a prescribed trace, the hand movement which is the light pen movement is immediately transformed into a digital signal through the use of the software prepared, the light pen in this case behaved as a data acquisition tool, where movement of this pen is reflected as a change in position on the computer screen. An important point about this type of data capturing is that no real contact between the subject undertaking the test and the mains electricity is established, which makes the test very safe and agrees with (Troyk, R. 1999)

The software designed for this work is written using Visual Basic 6 which is a Microsoft windows programming Language. To speed up the execution time and minimize the program size, programming is based on the structure known as Object Oriented Programming, where Subroutines and Functions are used extensively throughout the work. This is important in checking for the onset of hand movement and hence its deviation and time duration.

A control group of different ages in this case from 6 to 61 years is considered. They are all of good state of health with no previous muscular or physiological medical history regarding their hands.

The population consisted of 29 subjects, 24 were Males and 5 are Females. The subjects are subdivided into three classes: 6 children aged 6 to 16, 17 middle age, aged 16 to 45 and 6 old aged 46 to 61 years.

Test was conducted in the same way used by (Roger, 2002), with the replacement of the mouse by a light pen. It was found that light pen had no friction with the pad as was the case for the mouse. Horizontal displacement (Widths) of the lines as shown in the Fig.1 is kept at an approximate value of 12 cm to give the subjects a reference size of the needed displacement.

Lines drawn are found again to have minor deviation from a pure datum and not fully straight and are of the form shown in the doted parts of Fig.1.

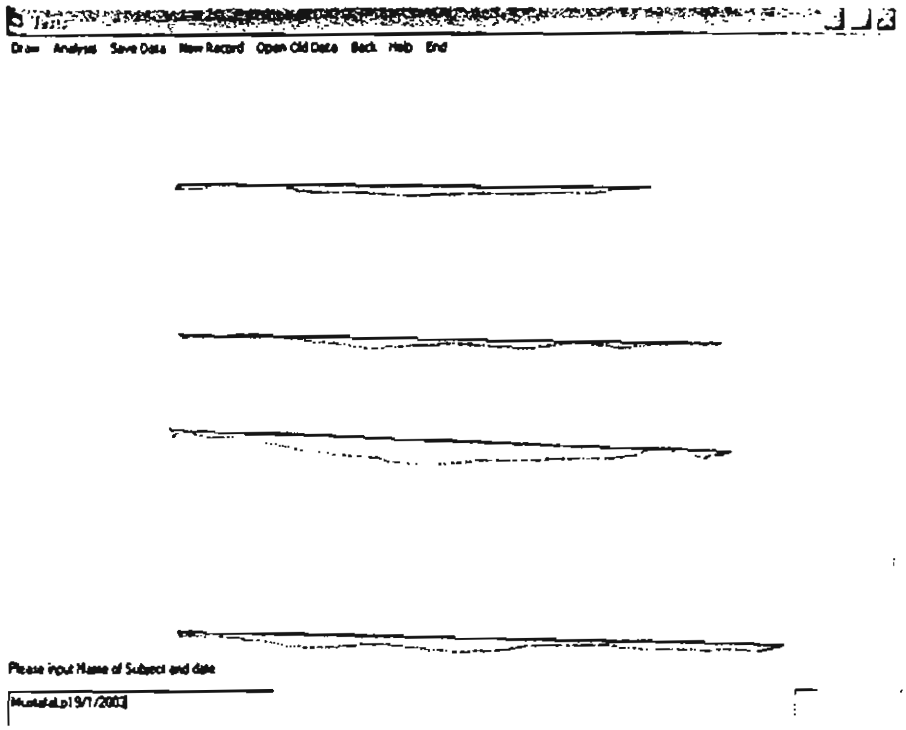

Fig.1: Actual hand movement represented by dots, best-fit line is the continuous segment.

Points representing hand movement from start to end are recorded as a set of points with their X and Y coordinates, and are stored in arrays. Each line is represented by an array with the starting and finishing time for further analysis.

Tests were repeated up to ten times by every volunteer to get as natural hand movement as possible. All volunteers were familiar with the use of computer.

An Option Draw in the programs menu bar is used after completing the test to make visible the trace of the stored data of the hand movement. It can show the continuous lines representing the resultant or ideal movement of each test; where lines are drawn from the starting point to the end point as shown in straightened part of Fig.1.

To avoid measurement error multiple tests were performed for every subject, to detect the variation between measurements of the same movement by the same individual (Martin and Douglas, 1996; Richard, 1999). The unavailability of enough female volunteers in this test reduced the chance of comparing the performance of males and females.

Fig.2 shows an example of the output of the program used in the analysis. It can be seen that each movement is referred to by a line number, below it appears many parameters such as Height which represents the vertical deviations of the hand movement, Width which represents horizontal deviations and Time which represents the duration of the movement etc.

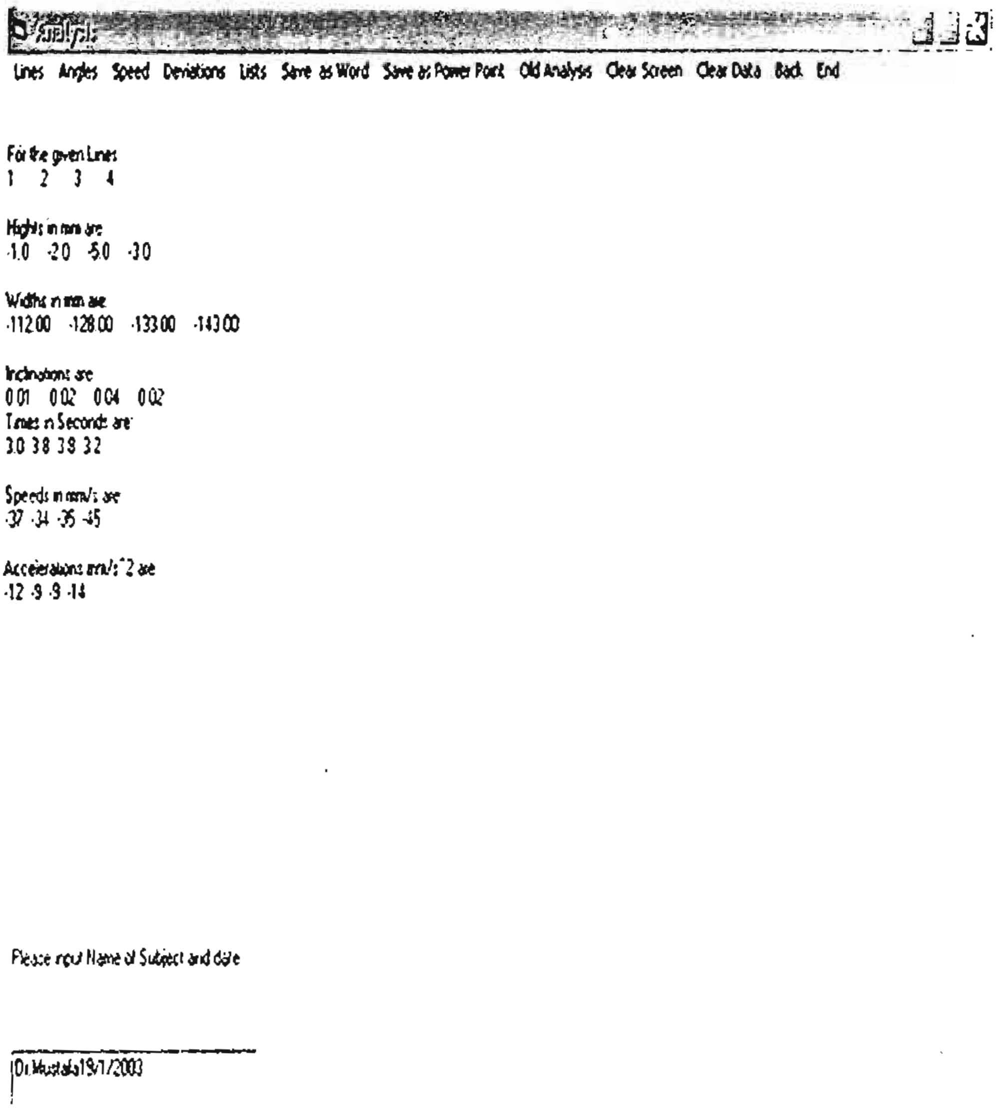

Fig.2: Line numbers and their corresponding parameters.

The parameters used are defined as follows:

Deviation (Height in mm) = Peak to Peak vertical deflection.

Duration (Time) = Time of onset of hand movement – Time at which hand comes to rest.

Deviation of hand movement from the perfectly horizontal track is noted, which proves an upward or a downward motion. This deviation is therefore positive if the movement is upward and negative if movement is downward, and since deviation is needed whether in the positive or the negative direction, therefore the modulus of the negative deviation is first worked out, and then the maximum deviation is calculated. The net value represents the true amount of deviation of the hand from the horizontal datum, where both deviations are forms of an overshoot.

At the end of every test the results are stored in the form of bitmap files as they actually appear, using menu option Save as Power Point, as shown in Figs. 1 and 2. This task is also programmed throughout the software with the other options that appears in the menu bar. Microsoft PowerPoint application (Majdee, 1999) is very handy for data storage because of the true image that it can keep and also because comparing different tests can be made at a glance (Mark, 2001).

The duration of movement is measured using the timer of the personal computer (system clock). Visual Basic6 enable the user to capture signal at a rate of 1ms, therefore it was possible using the software provided to take readings at 20ms therefore slowing the rate of data collection by a factor of 20.

III - Results

The sample test shown in Fig.1 is for one random subject, which demonstrates certain points:

1- Gaps between the doted part and the straight line indicate that deviation exists for all tests and therefore pure horizontal movement is not possible.

2- The values of the parameter heights shown in fig.2 which is the magnitude of deviation is far from 0, whether in the positive or the negative direction.

3- Deviations vary from test to test.

4- Deviations vary within the single test, as can be seen from the gaps between the dots and the straight lines; this can also be seen from the results shown in Fig.2 of the parameter Heights where its magnitude is given as -1 for line number 1 and -5 for line number 3. The same thing is noticed for other lines, similar variability is noticed for other subjects.

Measurements of Deviation

Deviations are measured as a function of age for the whole population and are shown in Fig.3:

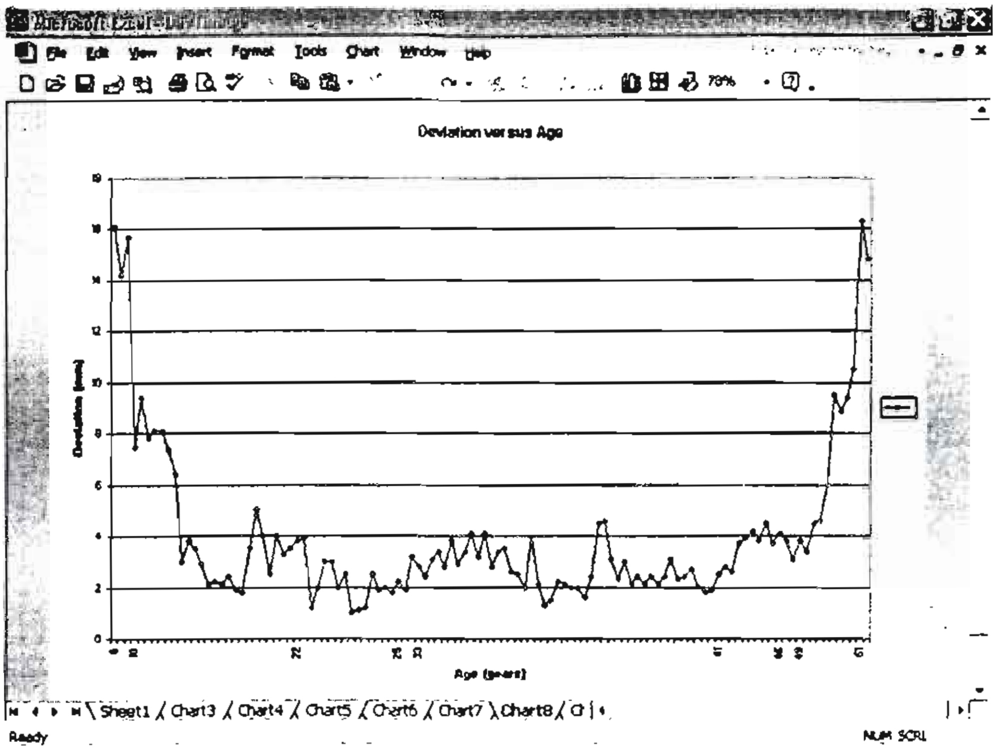

Fig.3: Deviation versus age for all subjects.

As can be seen from the results of Fig.3, three separate regions can be observed as summarized in the table below:

Table 1: Age Range versus Deviation.

Age range (years)	Deviation (mm)	
	minimum	Maximum
6 – 14	4	16
16 – 45	1.1	4
46	4	16.3

It can be noted that this deviation is largely distributed even within the same age range, for this reason the average of deviation is measured and the results are shown in Fig.4:

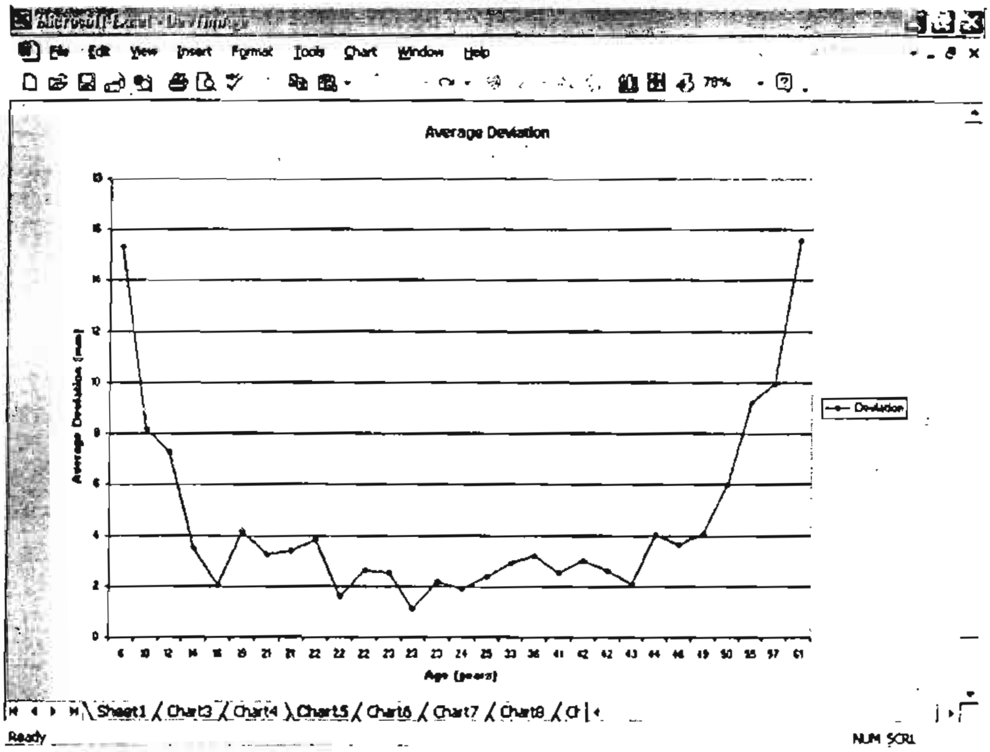

Fig.4: Average deviation versus age for all subjects.

The results illustrated in Fig.4 are summarized in Table 2.

Table 2: Average Deviation versus Age.

Age range (years)	Average Deviation (mm)	
	minimum	Maximum
6 – 14	3.8	15.2
16 – 49	1.5	4
50	4	15.7

This shows that considering the actual data leads to a wide variation compared to lower ranges obtained from the averages.

A mathematical formula is derived using the slope calculation process to express the dependence of Deviation on Age as follow:

$$D = S * G + C \quad \text{......} (1)$$

Where D is the deviation in mm, S is the slope for each age group, G is the subject's age in years and C is a constant depending on subject's age.

For subjects aged 6 to 16 years S=-1.32 and C=2G

For subjects aged 17 to 49 years S=0.014 and C=2

For subjects aged 50 to 61 years S=0.86 and C=-G/2

Measurements of Time

Fig.5 shows the tests results:

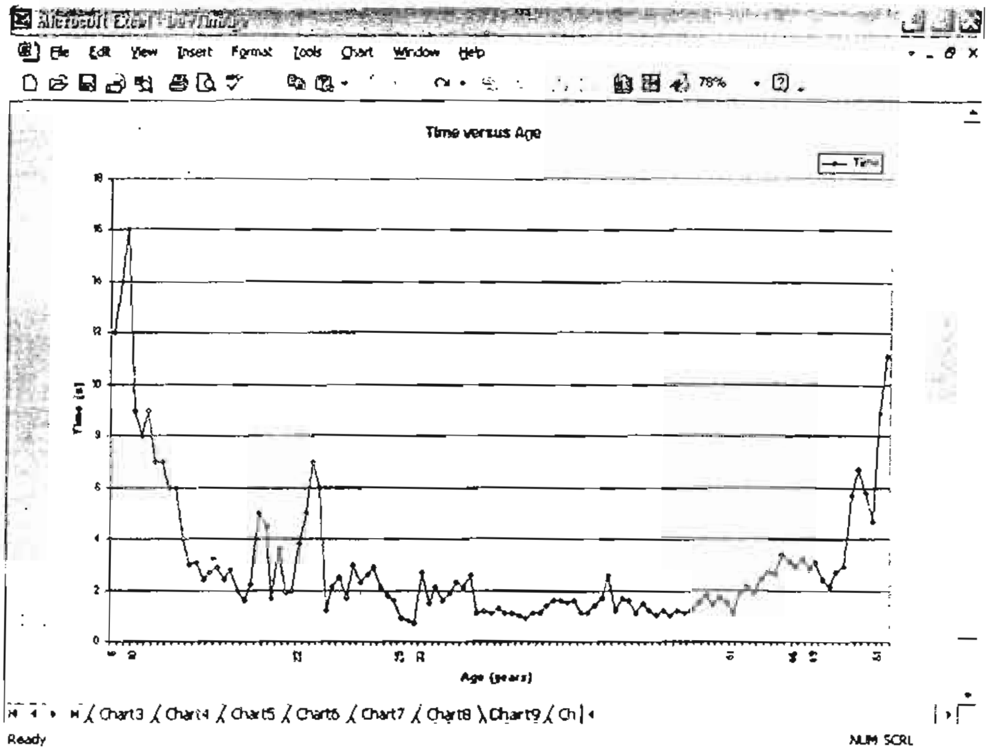

Fig.5: Test duration (Time) versus age.

As can be seen from the results of Fig.5, three separate regions can be observed as depicted in Table 3:

Table 3: Age Range versus Duration:

Age range (years)	Duration (s)	
	minimum	Maximum
6 – 16	2.9	16
16 – 51	.8	7
52	3	11.3

It is clear that the average of Duration is needed to reduce the diversity in the results, and is shown in Fig.6:

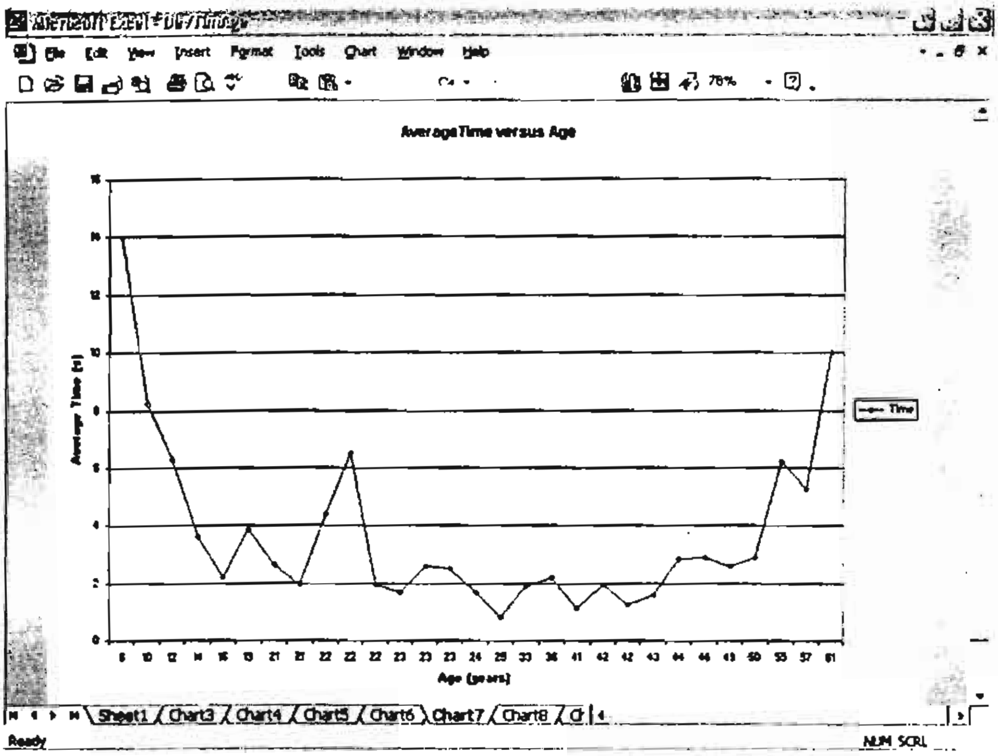

Fig.6: Average Test duration (Time) versus age.

As can be seen from the results of Fig.6, three separate regions can be obtained. Their values are depicted in Table 4.

Table 4: Average Duration versus age:

Age range (years)	Average Duration (s)	
	minimum	Maximum
6 – 16	2.2	14
16 – 51	.8	4.4
52	2.5	10

Figure 7 shows the collective deviation and duration versus age where both parameters seem to have certain degree of correlation with age for the three ranges considered.

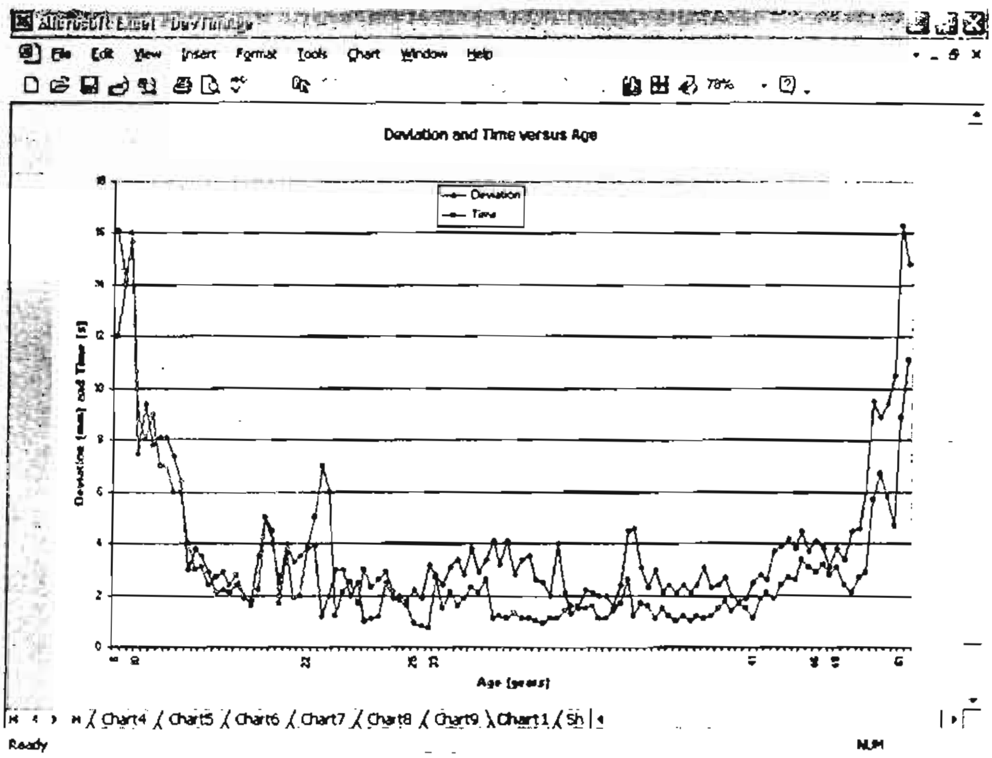

Fig.7: Deviation and Duration versus age.

Figure 8 illustrates the average deviation and duration versus age, where both parameters also seem to have certain degree of correlation with age for the three ranges considered.

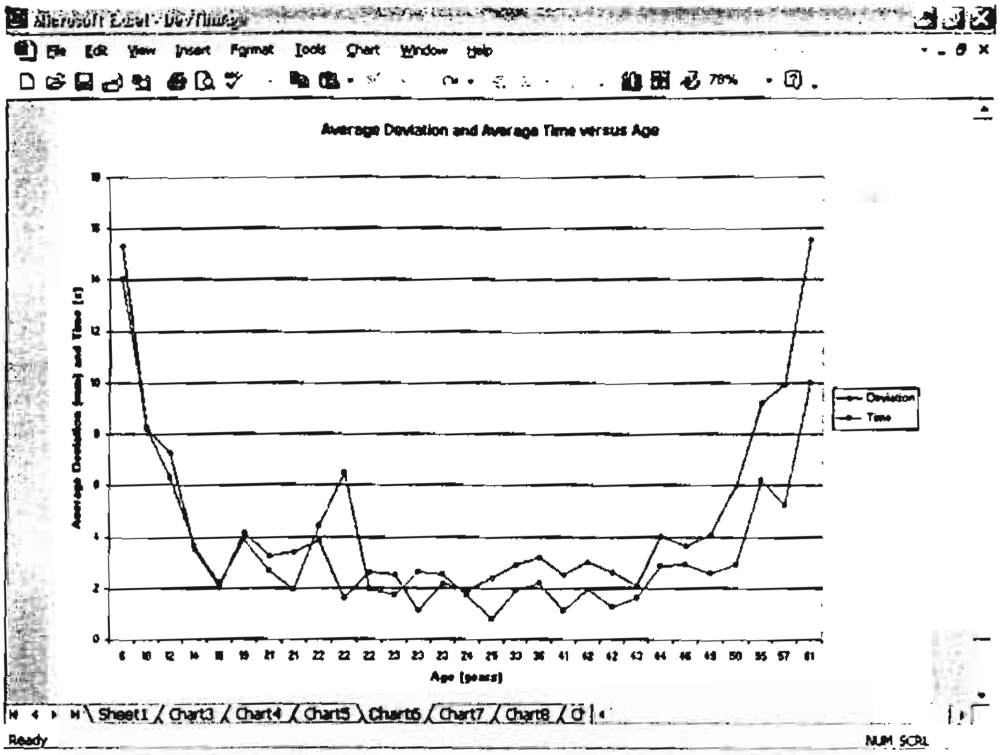

Fig.8: Average Deviation and Average Duration versus age.

A mathematical formula is derived using the slope calculation process to express the dependence of Time on Age as follow:

$T = S * G + K$ .... (2)

Where T is the duration in s, S is the slope for each age group, G is the subject's age in years and K is a constant depending on subject's age.

For subjects aged 6 to 16 years S=-1.19 and K=-G

For subjects aged 17 to 46 years S=0.043 and K=1.5

For subjects aged 47 to 61 years S=0.57 and K=-G/3

Tables 5 to 8 below indicate the following points:

1- Deviation with Age has strong Correlating with negative value for control aged less than 16 years, an indication of reduced deviation with increased age. but for subjects between 16 years and 46 years correlation is positive and equal to 0.43 an indication of steadiness, but for old aged control correlation is equal to 0.96 which again an indication of large variability with age. But for all groups correlation is equal to 0.21 which proves the necessity for dividing the population into three different ranges with each group has distinct behavior.

2- Time and Age has similar behavior to that of deviation and age (except that negative values are calculated for group with age 16 to 46 years and all ages) an indication of reduced dependence on age.

3- Correlation between Deviation and Time is found equal 0.86 which indicates strong dependence between the two parameters.

4- Correlating average Deviation with age and average Time with age behaved in the same way to that mentioned before and ascertain the results obtained.

Table 5: Correlation of Age (years) with Deviation (mm)

Age Range	Correlation Value
All Ages	0.21
6 _ 16	-0.96
16 _ 46	0.43
49 _ 61	0.96

Table 6: Correlation of Age (years) with Time (s)

Age Range	Correlation Value
All Ages	-0.14
6 _ 16	-0.99
16 _ 46	-0.23
49 _ 61	0.98

Correlation of Deviation (mm) with Time (s) = 0.86

Table 7: Correlation of Age (years) with Average Deviation (mm)

Age Range	Correlation Value
All Ages	0.20
6 _ 16	-0.99
16 _ 46	0.17
49 _ 61	0.98

Table 8: Correlation of Age (years) with Average Time (mm)

Age Range	Correlation Value
All Ages	-0.14
6 _ 16	-0.99
16 _ 46	-0.33
49 _ 61	0.95

Correlation of Average Deviation (mm) with Average Time (s) = 0.87

The above results of correlation strengthen the assumption made earlier in the introduction that hand movement is affected by age.

IV - Conclusions

Hand movement is analyzed in terms of its Vertical Deviation from a prescribed horizontal track and the Duration of the movement; this was considered as a function of the subject age.

Vertical Deviation is > 0 and is smallest for middle-aged subjects. Deviation is inversely proportional to increased age for young subjects, and directly proportional to increased age for old subjects and steady for middle-aged subjects. Deviation is dependent on Duration.

Results of correlation proves that hand movement is affected by age. Two mathematical formulas are presented; the first expresses the dependence of deviation on age while the other expresses the dependence of time on age.

Software prepared is proven adequate for the analysis and presentation of data, and in quantizing the effect of age and duration on vertical Deviation in horizontal hand movement.

References

1. Alan. N, 1997. Prevalence of arm movements in patients with coronary heart disease: case-control study. British Medical Journal, 314: 122.
2. Andrew, M., and David, E., and Watts, W. 1997. Movement Disorders: Neuralgic principles and practice. New York: McGraw-Hill, 1931-1932.
3. Cleary, H., and McKendrick. 2002. Hand-arm vibration syndrome may be associated with prolonged use of vibrating computer games. British Medical Journal; 301:324.
4. Deitel, h., and Deitel, P. 1999. Visual basic 6: New Jersey: prentice hall, 11-41.
5. Jackson, A. 1980. Automated Electrooculography a microprocessor Application example. Journal of Medical Engineering and Technology, 4 (6): 34-45.
6. Leigh, R.J., and D.S. Zee. 1983. The Neurology of Eye Movements. London: F.A. Davis, 30-40.
7. Majdee, M.A. 1999. Visual Basic 6, Egypt: Arabia for computer science, 15-22.
8. Marcus G. Pandy, 2001. Computer modeling and simulation of human movement: Annu. Rev. Biomed. Eng. 2001, Vol. 3: 245-273.
9. Mark, M. 2001.Windows Xp Professional. Alamnda: Sybex Inc. 10-26.
10. Martin and Douglas, 1996. Statistics Notes: Measurement error. British Medical Journal; 313: 744.
11. Microsoft Visual Basic 6.0, MSDN. for 32-bit Windows development. Microsoft Corp, U.S.A. 1998.
12. Muheilan M. 1999. Measurement of Eye Velocity Gain as a Function of Frequency. Abhath Al-Yarmouk, 8: 101-116.

13. Muheilan M. 2003. Presentation of Medical records. Dirasat, Engineering Sciences, Volume 30, No. 1, 51-61.

14. Polla, D. A.Erdman, W. Robbins, D. Markus, J. Diaz, R. Rizq, Y. Nam, H. Brickner, A. Wang, and P. Krulevitch. 2000. Microdevices in medicine. Annu. Rev. Biomed. Eng., Vol. 2: 551-576.

15. Richard A. Robb, 3-D. Visualization in Biomedical Applications Annu. Rev. Biomed. Eng. 1999, Vol. 1: 377-399.

16. Roger A, 2002. A measured response to hand arm vibration. British Medical Journal; 301:324.

17. Shipley M, 1995. Pain in the hand and wrist. British Medical Journal, 1995; 310:239-43.

18. Tony M, et al 2001. Biomechanics of Tubercular bone. Annul. Rev. Biomed. Eng. 2001, Vol. 3: 307-333.

19. Troyk, R. 1999. Injectable Electronic Identification, Monitoring, and Stimulation Systems. Annu. Rev. Biomed. Eng., Vol. 1: 177-209.

Appendix 1:

```
Option Base 0

Private Sub mnuVertical_Click()

List1.Visible = False:List2.Visible = False:Call Cls

For count = 0 To lim – 1 : vert(count) = finalpos(count) - pos(count)

Next:Print

For count = 0 To lim – 1 : vert(count) = FormatNumber(vert(count), 1)

Next:Print

Print "For the given Lines:"

For count = 0 To lim – 1 : Print count + 1 & Space$(7);

Next count:Print:Print:Print "Vertical in mm are:"

For count = 0 To lim – 1 : Print vert(count) & Space$(5);

Next count:Print

For count = 0 To lim – 1 : horizontal(count) = newpos(count) - fp(count) : Next

For count = 0 To lim – 1 : horizontal(count) = FormatNumber(horizontal(count), 2)

Next count:Print:Print "Widths in mm are:"

 For count = 0 To lim – 1

Print horizontal(count) & Space$(5);

Next count:Print : For count = 0 To lim - 1

If horizontal(count) = 0 Then

horizontal(count) = horizontal(count) + 0.001 : End If : Next count

For count = 0 To lim – 1 : ok(count) = vert(count) / horizontal(count) : Next count

For count = 0 To lim – 1 : ok(count) = FormatNumber(ok(count), 2)
```

```
Next count:Print:Print "Vertical Inclinations are:"
For count = 0 To lim – 1 : Print ok(count) & Space$(5);
Next count:Print
End Sub
Private Sub mnuVertical Deviation_Click()
List1.Visible = False:List2.Visible = False
last = 0
Dim old As Integer
   For old = LBound(Atthispoint) To UBound(Atthispoint)
   If Atthispoint(old) > last Then
   last = Atthispoint(old):    End If
Next old:nwt = 0
Dim c As Integer
   For c = LBound(blast) To UBound(blast)
   If blast(c) > nwt Then
   nwt = blast(c):  End If :      Next c
Dim ve As Integer :   ve = 0
   For count = 0 To lim – 1:   ve = vert(count) + ve
Next count
Dim he As Integer :   he = 0
  For count = 0 To lim – 1:   he = horizontal(count) + he
Next count
End Sub
```