Women's College for Arts,
Science and Education
Department Mathematics

Validation of Cavalieri Method for Irregular Volume Estimation

A thesis submitted for fulfilment the degree of
Philosophy Doctor of Sciences in Mathematics

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APPROVAL SHEET

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Validation of Cavalieri Method for Irregular Volume Estimation

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QUALIFICATIONS

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AIM OF THE WORK

Measuring irregular sizes has special significance in the world of mathematics because of its critical applications in the world of medicine. Anatomy structure volume and physiology function can be accurately estimated in vivo from a stereological estimation procedure. Specimens or organs are sections by a series parallel planes method such as computed tomography (CT) or magnetic resonance imaging (MRI) using the Cavalieri principle of modern designed stereology (Wang and Doddrell,2002; Acer et al.,2011; Acer et al.,2012). Applying stereological methods to tissue or organ section allows us to estimate the geometrical properties of the objects contained in the sections.

The point-counting grid, which has point sets with distinct densities on a transparent sheet, can be used to estimate the cut surface areas of the image The point-counting method consists of overlaying each selected section with a regular grid of test points that is randomly position, the total number of test points hitting the investigated structure on the sections is counted, and the unbiased estimation of volume can be done by using volume estimation formula that was described in this thesis. Using “coefficient of error” (ce), researcher can evaluate the reliability for the point density of the grids and sectioning

intervals (García-Fiñana,2003; Gundersen, and Jensen,1987; Howard and Reed, 2005).

Different methods have been employed for the determination of the irregular anthropometric organ (anatomic) volume such as Archimedes procedure (water volume displacement), Cavalieri points counting methods and Monte-Carlo simulation method using MATLAB software method, (Mills and Tamnes, 2014; Ertekin et al., 2013) . The results were compared statistically with the values obtained by the three different methods.

The objectives of this work are to:

1- Evaluating and measuring irregular shape subject's volume through three different types methods. This can be done by I. Using Archimedes principle of measuring the volume water displacement. II. Points counting method through applying Cavalieri principle by using Easy Measure software. III. Monte Carlo Simulation methods by using MATLAB software.
2- Determine and measuring the absolute error for each measurement methods used to measure irregular shape subjects to find out the most precise estimation measurement among the three procedures that mention previously.
3- Investigating the effects of the chronic stress pressure by the Israeli occupation on the growing brains volumes of Palestinian people. This can be done by comparing the volume brain of 30 young Palestinian subjects in age range

20-30 years with brain volumes of 30 young British subjects taken British people at year 2005.

To accomplish these objectives, the following procedures have to be followed:

1- Irregular shape volume estimation thought Archimedes principle for floating subjects, this can be done by taking irregular three dimension (3D) sold subjects and then measure its volume thought Archimedes principle for floating subjects, this can be done by added amount of water into a graduated cylinder with markings for every mL, the liquid volume will be read after that submerged totally irregular volume in the cylinder, the new volume of liquid will be readied again, the difference in volume will be the volume of irregular volume. For the purpose of measuring the variance of the volume of submerged objects, this procedure will be repeated eight time in succession.

2- Scan this irregular subject by 1.5 T Philips magnetic resonance installed at the hospital of An- Najah University in Nablus in Palestine. To measure total size of this subject the Cavalieri method were applied then the García-Fiñana Formula was used to measure the variability among sections (the coefficient of error of measurement).

3- Monte Carlo Simulation methods were used to measure the same irregular shape volume this can be done through MATLAB processing image slices image, each image slices were viewed on MATLAB screen and it converted into specific logical dimensional matrix according to the length and width of the image resolution, the target area in each image slice was determined and it turned into a matrix so

that they are part of the overall matrix of irregular volume estimator, the pixels in each target area was counted the total number of the pixels in the image is counted and also a matrix with same size is created, the ratio between the lengths of images matrix were calculated and multiplied with the total area of the image.

T1 weighted image of the 30 young male Palestinian subjects studies at Arab American University performed with an MRI scanner installed at An- Najah Hospital University. The stereological method to estimate their brain volumes after they been scanning have been investigated. Subject in this age range are the focus on order to match the sample condition that had been acquired from British people on year 2005. After the brains volumes measured by using (SPSS program) the t-test will be carry out on order to see any significant difference between Palestinian and British brains. The effectiveness of the continuous stress on Palestine by Israeli occupation will be investigate also.

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كلية البنات للآداب والعلوم والتربية
إدارة الدراسات العليا

فحص / مناقشة تاريخ موافقة مجلس الكلية على تشكيل لجنة الحكم والمناقشة في / / م ، وتتكون من :

١. **الأستاذ الدكتور /**
٢. **الأستاذ الدكتور /**
٣. **الأستاذ الدكتور /**

فحص / مناقشة تاريخ موافقة مجلس الكلية على التوصية يمنح الطالب درجة في / / م.

الموظف المختص **مدير الإدارة** **أ.د./ وكيل الكلية**

Abstract

This study is composed from two phases the first phase is concentrate on the measuring irregular sizes in mathematics world this done by Archimedes principle, Cavalieri with points counting method and Monte-Carlo simulation method using MATLAB software. Absolute error for Archimedes and simulation Monte-Carlo method was done while coefficient of error for Cavalieri with point counting method was done thought Garica equation (2003). It was founded that the absolute error for Archimedes was 55.56, absolute error for Monte-Carlo was 10.65 and coefficient of error for Cavalieri point counting method was to 0.760891. This indicated that the Cavalieri method for most famous methods used to estimate the irregular volume using points counting measurements with Marta equation for measuring the coefficient of error deserves all the attention and should be applied when irregular volume like this situation.

Second phase is concentrate on the quantitative volumetric magnetic resonance imaging techniques to explore the neuro-anatomic correlates of chronic, combat stress disorder in 30 young undergraduate Palestinian subjects whom suffering from continuous strong stress in their life spam as a result from Israeli occupation and compare their brain volumes with 30 young undergraduate British people whom doesn't

suffering from any difficulty during their life. t-test was conducted to check the differences in the volume of hippocampus. There was a significant mean effect of the left hippocampus volume (p=0.02) and right hippocampus volume (p=0.003). Indicate that the mean volume of hippocampus volume in the first British male group is significantly larger than hippocampus volume in the second Palestinian group. Paired t-test was conducted to investigate the effect of laterality (different between right and left hippocampus volume).

There were no significant different between left and right hippocampus (p=0.589) for British group, and (P=0.788) for Palestinian group subject, there was no significant difference in temporal lobe and brain hemisphere volume for left and right volume between two group (British and Palestinian subjects) (p=0.518) for left and (P= 0.668) for right for temporal lobe) while (P=0.345) for left hemispheric volume and (P= 0.593) for right hemispheric volume), paired t-test indicated there was no difference in right and left temporal lobe and hemispheric brain volume for both group (British and Palestinian subjects). Study finding of decreased hippocampal volume in chronic stress subjects is consistent with results of other investigators which suggests that chronic stress may damage the hippocampus and this can be consider as risk factor for reduction hippocampus volume under the combat area exposure.

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