Development of a Model for Recognition of Ergonomic Considerations Required for Structuring of CAD Packages to Improve Usability and User Productivity

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Abstract- **The knowledge of ergonomics is not new to the man. The development of ergonomic concepts can be seen applied from the Stone Age to the era of industrial revolution. Today is the age of Information Technology revolution. Every aspect of human life is getting automatized. The use of computer technology and application of it in everyday life has become common. The use of various software is becoming popular for diversified areas. The (CADD) Computer Aided Drafting and Designing is one such area which is very popularly being applied to solve important industrial problems.**

The study aims to determine what ergonomic considerations are important to improve two aspects of user's comfort, usability and user productivity. The definition of these two terms is very well described in literature. The study aims to improve usability and fatigue productivity (especially eye fatigue) through experimental study with eye movement tracker. The literature defines a specific behavior of fatigue against productivity. The study is concerned about this eye fatigue productivity for an average expert user for the desired CADD packages.

Keywords –CADD, Software Ergonomics

I. INTRODUCTION

The application of Human Factors Engineering for design of a system is an area of ergonomics which is evolving rapidly now days. There are various practices, principles and rules defined by various researchers and practitioners from ergonomics, for designing of Systems suitable for the user through ergonomic considerations. Application of ergonomic concepts finding its wide usage in the software technology today termed as Graphic User Interface.

Graphic user interface has been studied for a long time but there is no clear evidence of study of GUI of CADD packages, taking into consideration ergonomic requirements. There are two important terms, usability and user productivity.

The term "usability" actually as per an ISO definition: *"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use."*

II. NEED OF STUDY

Computer Aided Design and Drafting has helped the designers to integrate various wide ranges of concepts into single design. The CADD packages today can enable the designers to incorporate the concepts like Design for Manufacturing, Product Life Cycle, Finite Element Analysis, Reliability, etc.

The CAD packages don't limit the user to only creating the concept design or failure testing. The PDM and PLM packages hasenabled the designers to reach the need of the customers and helped improve design scope and efficiency.

Perhaps, increased capabilities of CADD packages has brought into increased complexities. Top endsystems offer the capabilities to incorporate more organic, aesthetics and ergonomic features into designs. Freeform surface modeling is often united with solids to allow the designer to create products that fit the human form and visual requirements as well as they interface with the machine.

Some software packages provide the ability to edit parametric and non-parametric geometry without the need to understand or undo the design intent history of the geometry by use of direct modeling functionality. This ability may also include the additional ability to infer the correct relationships between selected geometry (e.g., tangency, concentricity) which makes the editing process less time and labor intensive while still freeing the engineer from the burden of understanding the models. These kind of non-history based systems are called Explicit Modellers or Direct CAD Modelers.

This need of the era, of developing more advanced, powerful software tools, because of more dependence of the people on Information Technology, drives this research. Unless, the packages are designed taking into considerations the needs of the user, they will not be able to fulfill the requirements they are made for. It is found that, there have not been any specific guidelines available in the literature for designing the mechanical engineering oriented software packages like CAD and CADD packages.

The extensive use of these packages in industries today surely depicts the need of the Industry for making these packages more useful and productive.

III. FATIGUE AND PRODUCTIVITY

Eye fatigue or eye strain is a common and annoying condition. The sign include itching, tired, and burning eyes. This type of eye fatigue or eye strain is sometimes known as computer visionsyndrome. It affects about 50%-90% of computer workers. [6] Some calculations say computer-related eye symptoms may be responsible for up to 10 million primary care eye examinations each year. People usually blink about 18 times a minute. This naturally refreshes the eyes. But studies suggest that people only blink about half as often while using a computer orother digital device. This can result in dry, tired, itching, and burning eyes.

It can be found that there is a close relation between fatigue and productivity. The literature explains a following graph which

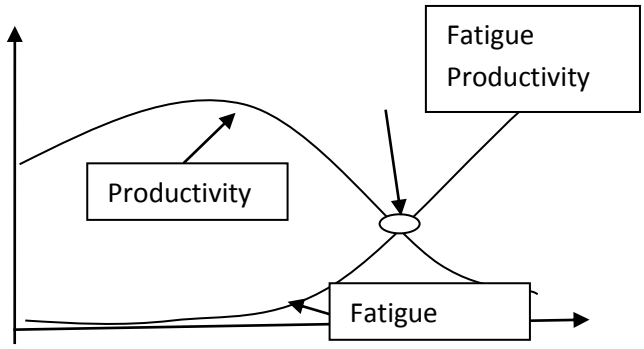

Fig.1. Optimization Graph Showing Fatigue Vs Productivity

This graph depicts that a very close association between user productivity and user fatigue exists. The study aims to understand the behavior of software user productivity and eye fatigue. As the graph is plotted on a time scale, the objective is to increase the span of association between productivity and fatigue so as to improve overall fatigue productivity for the user.

The research will need to answer following questions

- What is eye fatigue?
- What is fatigue productivity?
- What are linkages with fatigue productivity?
- How fatigue productivity can be determined?
- How we can implement it?
- What are the benefits of fatigue productivity?

The research needs to follow some assumptions as:

- Fatigue occurs at 100 saccades. (Eye tracking study)
- Fatigue occurs at 80% of screen occupied.
- Only cognitive load is involved.

IV. MEASUREMENT OF EYE FATIGUE

The objective of study can only very well be fulfilled with an eye tracking system. The system is available with different options. The eye tracking is mostly found to be used for Behavioral Research in Design and Usability. Eye tracking is used to define structures via image processing and tracking and track the spatial challenges over time. Typical parameters: caliberated are translation & rotation of eye, pupil dilation, etc. Sampling rates vary from 25 – 1250 Hz (for one or both eyes.

Following terms needs to be understood in order to caliberate the system.

Fixations

- Fixations mean the eye being at (relative) rest
- Typical duration of fixations are 100 – 600 milliseconds
- Information from scene is gathered during this period
- Brain start processing data during this stop period
- Length of fixation often indicates information processing and/or cognitive activities

Saccades

- Saccades are fast jumps from one fixation to the other
- Average length of saccades is 20 – 40 milliseconds
- Vision is largely suppressed during saccadic movement
- Regressive saccades and saccade pattern can reveal confusion and problems in understanding

The system answers following questions

- Is visual representation everything?
- Do we see what we see?
- Do we recall all that we see?

The system helps in funneling of informaion in following way as described in figure

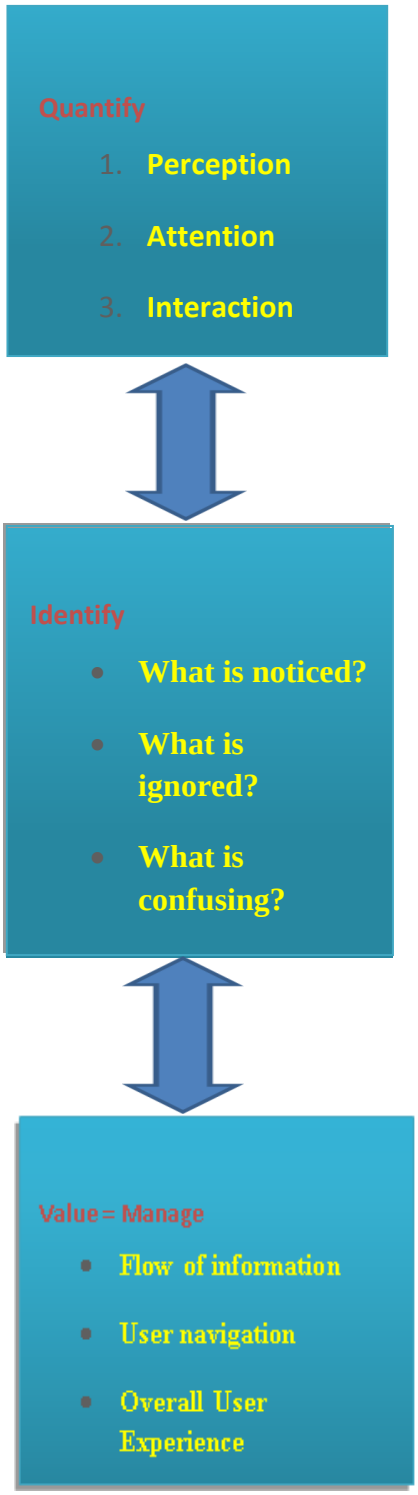

Fig 2. Funneling Of Information With Eye Tracking Study

The use of eye tracking system is popular in flowing application area

Experiment Design

1. Web sites
2. Web-based applications
3. Images
4. Text
5. Printed literature
6. Video
7. Screen recording
8. Real-world task

The advantage of eye tracking can be explained in following way.

Data Acquisition

- Simple setup
- Easy calibration
- Define demographics
- Robust tracking

Also the system can be very well applied for data analysis as

- Scanpath
- Heatmap
- Focus map
- AOI analysis
- Comparative statistics
  - Dwell time
  - Glances
  - Etc..

The broad area of applicability for eye tracking system can find its applications as depicted in following diagram

The key value examples for eye tracking system applicability includes

- Quantify behavior when accomplishing a task

- Look for pitfalls, misunderstandings, enhance exit interview
- Develop “ideal” behavior

- Compare company website to competitors

- Time to first fixation on key component
- Total dwell time on important region
- “Hit” ratio

- Validate multiple versions of a website

- Which is more usable during a task
- Which is more effective at communicating information

- Inner- & intergroup comparison of subjects
  - Drill into different demographics
  - Experience vs. novice

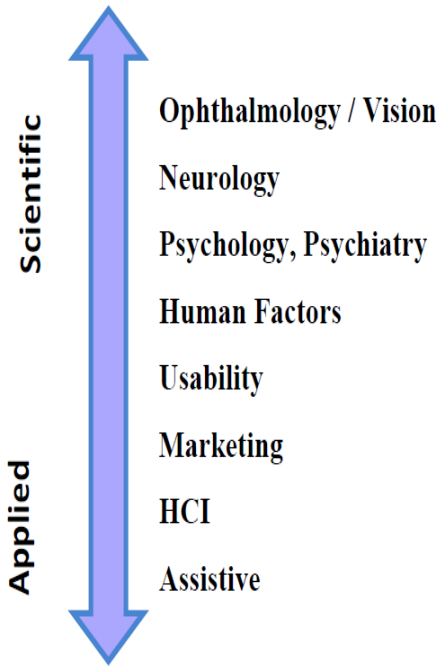

Fig.3. Application Areas of Eye Tracking Study

V. RESEARCH OBJECTIVES

The study discusses the present status of Software ergonomics and its contribution in the development of more user centered and ergonomically oriented software products. Software ergonomics can play a pivotal role in the process of standardization of thesoftware development process. It can make contribution to sustainable industrialdevelopment through innovation, product development and improvements in productivity, production process and systems. An understanding of these factors helps government, private sectors, banks and insurance in effective decision-making process. The purpose is to evolve simple rules based on a scientifically rigorous study.

The overall objective stated can be presented as the following objectives

1. To identify variables that are critical for developments of CAD software
2. To know the views of CAD software users regarding the extent to which each of the identified variables influences the usability and user productivity of this software.
3. Classification of variables identified earlier as contributing to the developments of CAD software into mutually exclusive and comprehensive factors.
4. To develop a program/software to assess and guide the user about productivity and usability of the existing CAD package.

VI. EXPERIMENTAL DESIGN

The experimentation will need to be carried out with detailed variations of working conditions. We have assumed three different variations of working conditions

A. No environmental treatments.
B. Work space designs as per ISO 9246.
C. Illumination conditions as per guidelines in ISO 9246.
D. Effect of personal factors like age, gender, ethnicity, etc.

Determination of fatigue point:
The eye fatigue occurs at approximate point of 50 saccades. We have designed a experimental table to carry out fatigue study.
The subjects will be studied with following various capabilities and variations

- Age of subject
- Gender of subject
- Present Skill level
- Comfort level to carry out work with various working conditions

Resources Required:

- Eye Movement Tracker and Tester.
- BGaze software to carry out desired analysis on eye movement
- Resources like access to various publications, IIT libraries.
- Subjects from Industry
- Subjects from Academia
- Subject students from Masters Course

It is found from the literature review that mostly the eye fatigue is associated with eye blink and saccadic movements. A flowing model can be predicted from the available information

No. of Saccades	A	AB	AC	AD	ABC	ABD	ABCD
40 Saccades							
60 Saccades							
80 Saccades							
100 Saccades							
120 Saccades							
140 Saccades							
160 Saccades							

Table I EXPERIMENTAL DATA COLLECTION TABLE

A statistical method known as BOOTSTRAPPING is found to be implementable.
The data will be grouped in different headings of age, sex, skill level, and will be studied under different ergonomic conditions of work like temperature, humidity, illumination level as directed in ISO 9246. The bootstrapping technique is useful for determining the associationbetween different factors and its associated variables.
It's supposed that the work will be carried in two stages. In first stage at the primary levelthe association between usability and productivity willbe determined from 11 different variables listed in the model below. A combination of traditional and novel approach is supposed to be a beneficial approach in the current situation of the study. The following diagram can explain the possible results achievable.

In the second sage a final model will be produced as described in the following diagram. The final model will get a picture for understanding of association between eye fatigue and user productivity with usability issues. This is called as path analysis.

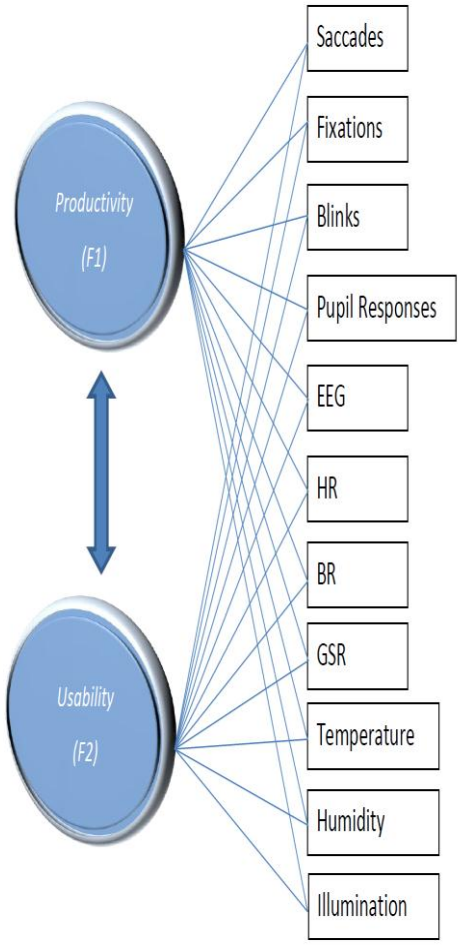

Fig. 4. Model Showing Preliminary Stage of Data Collection

The study also aims to understand the usability requirements from user's perspective. A study is required to be carried out from user's perspective with which a comparative between usability requirements from a developer's perspective and from a user's perspective can be analyzed. A simple hypothesis testing can be applicable along with a simple questionnaire tested and analyzed with using basic statistical methods.

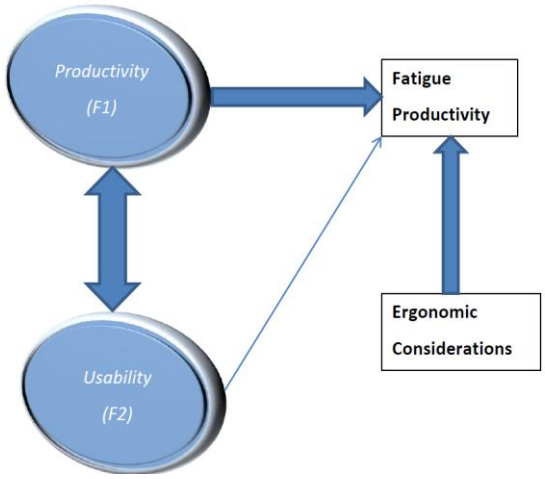

Fig. 5. Model Showing Final Stage of Data Analysis

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