CHAPTER 4
INTRODUCTION

Human-Computer Interaction (HCI) is involved with the sequence of user activities in direct manipulation/menu based interfaces. The sequence of activities consists of both mental and physical activities. The descriptive model of Norman (1986) and syntactic/semantic model of Shneiderman (2000) for HCI show that the interaction between user and computer requires both mental and physical activities. Physical activity describes the motor actions performed by the user, such as using the keyboard or mouse to provide inputs. The cognitive processes associated with using the computer is related to the mental activity. The cognitive processes are related to plan for the execution of system inputs and to interpret and evaluate system outputs. The knowledge and techniques of cognitive psychology are applied to the study of human-computer interaction [Shneiderman, 2000].

The user interface (UI) of a computer program is the part that handles the output to the display and the input from the person using the program [Myers, 1995]. The well-designed user interface makes an interactive system effective enabling user to concentrate on their work, exploration, or pleasure. The ability to perform routine activities quickly, effortlessly, and without conscious awareness is called automaticity [Logan, 1988a]. Automaticity is relevant and important construct for the study of human-computer interaction in general and for the study of
direct manipulation Interfaces in particular [Lim et al., 1996]. As interfaces become easier to use, they become harder to create [Myers, 1984]. Creating an environment in which users carry out tasks almost effortlessly requires a great deal of hard work from the designer. One study found that an average of 48% of the code of applications is devoted to the user interface, and that about 50% of the implementation time is devoted to implementing the user interface portion [Myers and Rosson, 1992].

Within computer science there is a growing awareness of the need for great attention to human factors issues. Proper attention to human factors principles and rigorous testing often leads to reduced cost and rapid development. The business case for a human-factors in computer and Information systems is strong [Klemmer, 1989; Chapinis, 1991; Landauer, 1995], as demonstrated by many successful products whose advantage lay in their superior user interfaces. Human factors principles and processes are used to design exciting interactive systems. The design of the interactive system is evaluated in terms of speed of performance. To promote effective designs, companies should run usability studies with users from each country, culture, and language community [Nielsen, 1990]. Some studies show that the total time required to complete a task in a direct manipulation interface will be less than in a menu based Interface [Lim et al., 1996]. The high speed of performance reduces the information processing and transmitting time.
The efficient design of interactive systems can reduce the information transmitting cost to about 20% to 30% in communication networks [Jayant, 1987]. The good interactive system is the key to communication networks which certainly affects every industry and service through significant qualitative and quantitative improvements, in providing information, designing products and services, tracking and responding to a variety of demands and supporting decision making.

The quadratic assignment problem (QAP) formulation for assigning 'n' facilities to 'n' mutually exclusive locations is the most typical model used, in manufacturing or interactive service systems. A classical QAP is formulated handling qualitative (subjective) factors and quantitative (objective) factors to obtain the layouts, using the layout procedures such as CORELAP, CRAFT, etc. The REL chart and travel chart (or from - to chart or flow diagram) are used to obtain the qualitative (subjective) closeness relationships and quantitative (objective) interactions, respectively between the various pairs of facilities.

The user interface components such as menus, buttons, scroll bars, and text input fields are known as widgets. In the widgets layout problem, the facility may be referred to as a user interface component. Some theories have explored the user interface components layout problem [Sears, 1992; Shneiderman, 2000]. Many authors have made their studies in the direction of user interface components layout design.
and analysis [Sears, 1992; Chuah et al., 1994]. The issues related to cognitive and perceptual actions are evaluated as the qualitative closeness relationships between the various pairs of components which are recorded in REL charts for each factor and the optimum layout is obtained, using CORELAP with the objective of maximizing the closeness relationship values between components [McCormick et al., 1982].

On the other hand, the issues related to physical activities in moving and pointing a mouse between the components are evaluated as the quantitative interactions which are recorded in a square matrix (or from - to chart) with value of a link attribute in the row and column representing a link in a flow diagram [Shneiderman, 2000] for each factor. The qualitative closeness relationship values and the quantitative interactions (workflows) are handled in the objective function of quadratic assignment model for the facilities layout problem. Then, the optimal layouts are obtained, using the layout procedures such as CORELAP, CRAFT, etc. That is, the tools and techniques of the facilities layout problems are found to be equally effective in the layout design of user interface components. Hence, there is one - to - one relationship between the facilities layout problem in a manufacturing plant and the user interface components layout problem in human - computer interface design.
Next section of the chapter presents the motivation for the present study. The objectives of the study are presented in section 2, and the chapter ends with the overview of the study in section 3. The contents of the chapter are briefly summarized at the end of the chapter.

1.1 MOTIVATION FOR THE STUDY

The problem of interactive system design varies from location and layout of facilities in a manufacturing plant to the layout design of the textual and graphical user interface components in human – computer interface. The user interface may be a direct manipulation interface, or a menu based interface. It has been found surprisingly that there is a sort of one-to-one relationship between arrangement of manufacturing facilities with that of the textual and graphical user interface components (icons). The closeness relationship ratings between the various pairs of components obtained from the REL chart are used to design the layout of the various controls and displays in an automobile or in the aircraft [Mc Cormick et al., 1982] with the objective of maximizing the closeness relationship score. Fortunately, there is much literature reporting research and experience from design projects with automobiles, aircraft, type-writer, home appliances, and so on that can be applied to the design of interactive computer systems [Shneiderman, 2000]. The design of interactive computer systems involves the problem of the textual and graphical user interface components layouts in the human – computer interface. The main objective of the textual and graphical
user interface components layout design is to increase the human comfort and decrease the fatigue, monotony, etc. of the user.

Graphical user interfaces were a setback for vision-impaired users, but technological innovations facilitate conversion of spatial information into non-visual modes [Poll and Waterham, 1995; Thatcher, 1994; Mynatt and Weber, 1994]. The US General Services Administrator's (GSA) guide, Managing End User Computing for Users with Disabilities (1991), describes effective accommodation for users who have low vision or are blind, users who have hearing impairments, and users who have mobility impairments. Enlarging portions of display [Kline and Glinert, 1995] or converting displays or braille or voice output [Durre and Glander, 1991] can be done with hardware and software supplied by many vendors. The flexibility of computer software makes it possible for designers to provide special services to users who have disabilities [Edwards, 1995; Glinert and York, 1992].

In the problem of interface design, the facility can be a text or graphical user interface component (icon). Also, the factors considered in manufacturing facilities layout problem as well as in textual and graphical user interface components (icons) layout problem are similar, thus paving the way for application of the layout techniques for the design of user-computer interface and several studies are already made in this direction [Sears, 1992; Chuah et al., 1994]. A theory,
taxonomy, or model that could help designers to predict performance for even limited range of users, tasks, or designs would be a contribution [Card, 1989]. This motivates the present study that focuses attention on using the layout techniques and tools for human–computer interface design.

The issues related to the cognitive and perceptual actions, namely, fatigue, attention, monotony, boredom, anxiety, fear, etc. might be considered as the qualitative factors. Users see a display of related user interface components (icons), move a cursor among the components, and perform the desired task. Data collection can include a wide range of subjective impressions or of subjective reactions that are qualitative, such as rating scales or rankings [Shneiderman, 2000], obtained from the REL charts concerned with the various users, viz., novice, intermittent, and expert. The GOMS (Goals, Operators, Methods and Selection rules) model that deals with the cognitive, perceptual and motor actions is used for the layouts of the textual and graphical user interface components [Chuah et al., 1994].

A more accurate prediction of performance is likely to come with metrics that integrate qualitative subjective reactions related to sequence of components (icons) and quantitative objective data related to the use of components [Shneiderman, 2000]. If users can accomplish frequent tasks by moving through a display in a top to bottom pattern,
then faster performance is likely, compared to that with a layout that requires numerous jumps around widely separated components of the display [Shneiderman, 2000].

The issues related to motor actions, such as frequency-of-use, interaction style, step-by-step work, all-at-once work, pace-of-interaction, etc. may be characterized as the quantitative factors. These vital issues have profound influence on the quality of the design of most interactive systems [Shneiderman, 2000]. As the frequency-of-use increases, so do the users desire to reduce the number of interactions and to increase the pace-of-interaction. Similarly, people who enjoy using computers may have very different performances for interaction styles, step-by-step work, all-at-once work, etc. A from-to (or travel) chart helps designers to record and convey the data that capture user experiences, for example, the number of interactions between the components. A flow diagram may also be used to record the data that capture user experiences. The thickness of the connecting lines in the flow diagram indicates the frequency (number of interactions) of the transitions [Shneiderman, 2000].

There are different qualitative approaches developed for the design of the layouts. Seehof and Evans (1967), Lee and Moore (1967), Muther and McPherson (1970), and Muther (1973) have developed algorithms based on qualitative criteria to obtain the final layouts. The qualitative
The quadratic assignment models are developed handling one qualitative factor and one quantitative factor with different range of values for the facilities layout problem, and hence either of these may be dominated by other factor. Hence, there is need to develop a quadratic assignment model, handling a normalized qualitative factor and a normal quantitative factor in the objective function for the layout design of textual and graphical user interface components. The normalized
The results obtained, using the qualitative approach with a single qualitative factor are not of practically acceptable quality, since all qualitative factors are aggregated into a single qualitative factor. In order to obtain the results that are of practically acceptable quality, it is required to propose a model, handling a number of normalized qualitative factors concerned with the various users viz., novice, Intermittent, and expert for the textual and graphical user interface components layout problem.

There is also a need to develop a quadratic assignment model and a construction layout procedure for the textual and graphical user interface components layout problem, handling a number of normalized qualitative and quantitative factor, concerned with users, such as, novice, Intermittent, and expert in different manner separately without the cost of assigning the facility to the location in the objective function. In the proposed model, the qualitative factors and quantitative factors are handled in different manner separately in order to obtain the results that are of practically acceptable quality. And also, the cost of assigning
facility to the location is not included in the objective function since the user interface components do not have weight and thickness and they are pixels that can be moved are copied in ways that represent real-world task objects (components) with feedback to guide users [Shneiderman, 2000]. The normalized qualitative and quantitative factors are assigned with unequal weights, so that the final layouts reflect the relative importance of each factor appropriately. A construction procedure that selects the pair of facilities with lowest composite criterion value to place far apart in the layout is used to obtain a good initial layout of the textual and graphical user interface components. Further, the initial layouts may be improved, using the existing improvement procedures.

Next section of the chapter presents the objectives of the study.

1.2 OBJECTIVES OF THE STUDY

The objectives of study are to develop the various quadratic assignment models for the design of an effective human - computer interactive system. The various quadratic assignment models of the facilities layout problem are critically analyzed in order to develop an alternate model for the problem of interactive system design that varies from the location and layout of facilities in a manufacturing plant to the design of the textual and graphic user interface components layout in the human - computer interface. The various objectives of study are given as follows.
1. To review the literature and analyze it to identify the problem of the study.

2. To analyze the various quadratic assignment models for the facilities layout problem in order to develop a quadratic assignment model, which handles multiple qualitative and quantitative factors including the cost of assigning the facility to the location in the objective function for the facilities layout problem and compare its results with that of an existing model.

3. To develop quadratic assignment models, handling one qualitative factor and one quantitative factor in the objective function for the textual and graphical user interface components layout problem.

4. To develop a quadratic assignment model, which handles a number of normalized qualitative factors in the objective function for the textual and graphical user interface components layout problem.

5. To develop a quadratic assignment model and a construction layout procedure, handling a number of normalized qualitative and normalized quantitative factors in different manner separately without the cost of assigning the facility to the location in the objective function for the textual and graphical user interface components layout problem.
Next Section of the chapter presents the overview of the study, in order to achieve the objectives.

1.3 OVERVIEW OF THE STUDY

The thesis is organized into 7 chapters. Chapter 1 presents the introduction to the problem of the study. This chapter contains the motivation for the study, objectives of study and overview of the study. The brief summary of this chapter is also presented at the end of the chapter.

The literature review of the work is presented in chapter 2. Section 2.1 presents the literature concerned with theories and models used in the design of human-computer interaction. This section also presents the literature concerned with the layout design of human-computer interface components. The literature concerned with single-objective facilities layout problem is presented in section 2.2. Section 2.3 presents the literature concerned with the various quadratic assignment models for the multi-objective facilities layout problem. The literature concerned with multi-factor facilities layout problem is presented in section 2.4. Section 2.5 presents the literature concerned with the various solution procedures for the facilities layout problem. Section 2.6 presents the qualitative and quantitative factors that affect the layout of user interface components. The chapter ends with the summary in which the contents of the chapter are briefed.
Chapter 3 presents the proposed multi-factor facilities layout model, which handles a number of qualitative and quantitative factors in different manner separately including the cost of assigning the facility to the location in the objective function. Section 3.1 presents the various models the facilities layout problem. The construction and improvement procedures for the multi-factor facilities layout problem are presented in section 3.2. Section 3.3 presents the proposed multi-factor facilities layout model, which handles a number of qualitative and quantitative factors in different manner separately in the objective function. The cost of assigning the facility to the location is incorporated in the proposed model so that its application may vary from the layout design of facilities in a manufacturing plant to the layout design of user interface components by altering its parameters. This section also presents the comparison of the results of the proposed model with that of an existing model, which handles a number of qualitative and quantitative factors in the same manner and the chapter ends with the brief summary.

Chapter 4 presents the proposed multi-objective facilities layout models as an approach 1 and an approach 2 for the textual and graphical user interface components layout problem. An approach 1 handles the distance weighted sum of one qualitative factor attribute values and one quantitative factor attribute values assigned with relative weights in the objective function. On the other hand, an approach 2 handles the distance weighted sum of one normalized qualitative factor
attribute values and one normalized quantitative factor attribute values assigned with relative weights in the objective function. Section 4.1 describes the user interface components layout problem. Section 4.2 presents the effect of the various qualitative and quantitative factors combined into two factors (objectives or goals), qualitative and quantitative in the layout design of user interface components. Section 4.3 presents the various facilities layout models that can handle qualitative and quantitative objectives in the objective function. Section 4.4 presents the approach 1 and approach 2 of an alternate model for multi-objective layout design of the textual and graphical user interface components. This section also presents the comparison of the results of an existing single-objective layout model and approach 1 of the proposed model. Further, the results of approach 1 and approach 2 of the proposed model are also compared. Finally, the chapter ends with the brief summary.

Chapter 5 deals with the proposed model for the layout design of user interface components, handling a number of qualitative factors in the objective function. Section 5.1 discusses the qualitative factors concerned with the various users that affect the user interface components layout. Section 5.2 presents the various layout algorithms based on the qualitative criteria for the facilities layout problem. Section 5.3 proposes a model for the layout design of the textual and graphical user interface components, handling multiple numbers of qualitative
factors in the objective function. This section also presents the comparison of the results of the proposed model with that of a single-objective approach, considering all qualitative factors aggregated into one qualitative factor for each user, and the chapter ends with the brief summary.

Chapter 6 presents a methodology for the user interface components layout problem, handling multiple numbers of qualitative and quantitative factors in the objective function. 6.1 presents the various qualitative and quantitative factors that affect the layout of the textual and graphical user interface components. Section 6.2 presents the existing layout methodology for the multi-factor facilities layout problem. Section 6.3 presents the proposed methodology that contains a model and a construction procedure for the multi-factor user interface components layout problem. Section 6.4 deals with the application of the proposed multi-factor facilities layout model and a construction procedure in the layout design of the textual and graphical user interface components. This section also presents the comparison of results of the proposed model and a construction procedure with that of an existing model and a solution procedure for the example task under consideration, and the chapter ends with the brief summary.

Chapter 7 of the thesis presents the results and conclusions of the study. Section 7.1 presents contribution of the study. Section 7.2
presents the computational results of the study. Section 7.3 presents conclusions of the study. The suggestions for further study are presented in section 7.4 and the chapter ends with the brief summary.

**SUMMARY**

This chapter presents the introduction to the human - computer interaction and the quadratic assignment models to design the user interfaces. Section 1.1 presents the motivation for the study, which describes the usefulness of quadratic assignment models for the layout design in human - computer interface. Section 1.2 presents the objectives of the study, and section 1.3 presents the overview of the study, which addresses the organization of the work.