AN INTERFACE BETWEEN CAD AND ENERGY ANALYSIS SYSTEM

Bharati Jog
Department of Computer Science
107 Ayres Hall
University of Tennessee
Knoxville, Tennessee 37996

ABSTRACT

During the architectural design process it is helpful to get the energy analysis at various steps. Using the knowledge obtained from energy analysis programs, a design can be improved during the next step. Today Computer-Aided Drafting packages are popular as drafting tools in the architecture profession and schools. Many software packages for energy analysis are also available. To promote such analytical design process, there is a need to develop interfaces between energy analysis systems and Computer-Aided Drafting packages to get the energy analysis using the drawing files. This paper describes the use of the interface between Computer-Aided Drafting system and energy analysis program as an analytical tool in the Computer-Aided Design process. Then it presents an interface developed between AutoCAD, a popular Computer-Aided Drafting tool, and CALPAS3, an energy analysis program.

1 INTRODUCTION

Computer-Aided Design and Computer-Aided Drafting are prominent areas of computer applications in architecture. Software packages like AutoCAD and MicroCAD are becoming very popular Drafting tools.

Another area of computer applications, "Energy Analysis" is also becoming popular among architects and engineers. Sophisticated systems such as CALPAS3 are available on the market to analyze energy consumption of buildings.

Energy analysis programs often require complicated and lengthy data of buildings to be punched by the user in a definite format. Thus to use these programs, the user needs to read the manuals and know the syntax to input data. As a result these programs are not used as widely as they should be by naive users, especially students. If a building is drawn using a Computer- Aided Drafting system such as AutoCAD, there is no way of using the drawing files as an information source for the input of energy analysis programs. One of the solutions for the above problem is to develop an interface between the energy analysis programs and the CAD system. The integrated system can be used as an analytical tool to improve a design.

The goal of this paper is to explain the concept of such an interface and then to describe a project of developing an interface between AutoCAD and CALPAS3.

In the next section, we will discuss the idea of an interface in general and how to use it as an analytical designing tool. Section 3 gives the project methodology. A brief description of the program is given in section 4. Section 5 gives the summary.

2 CONCEPT OF THE INTERFACE

Two or more independent programs/systems can be interfaced to produce an integrated system. An interface between two programs takes the output of one program and converts it into the input data for the other. This process may not be as simple as it appears. The programmer may need to handle problems such as compatibility, completeness etc. Many times auxiliary input is necessary. The auxiliary input can be obtained interactively from the user. This user interface needs to be friendly and simple. Another way to get auxiliary input is to read user-created input files. Figure 2.1 illustrates the concept of an interface.

This concept is the backbone of the project described in this paper.

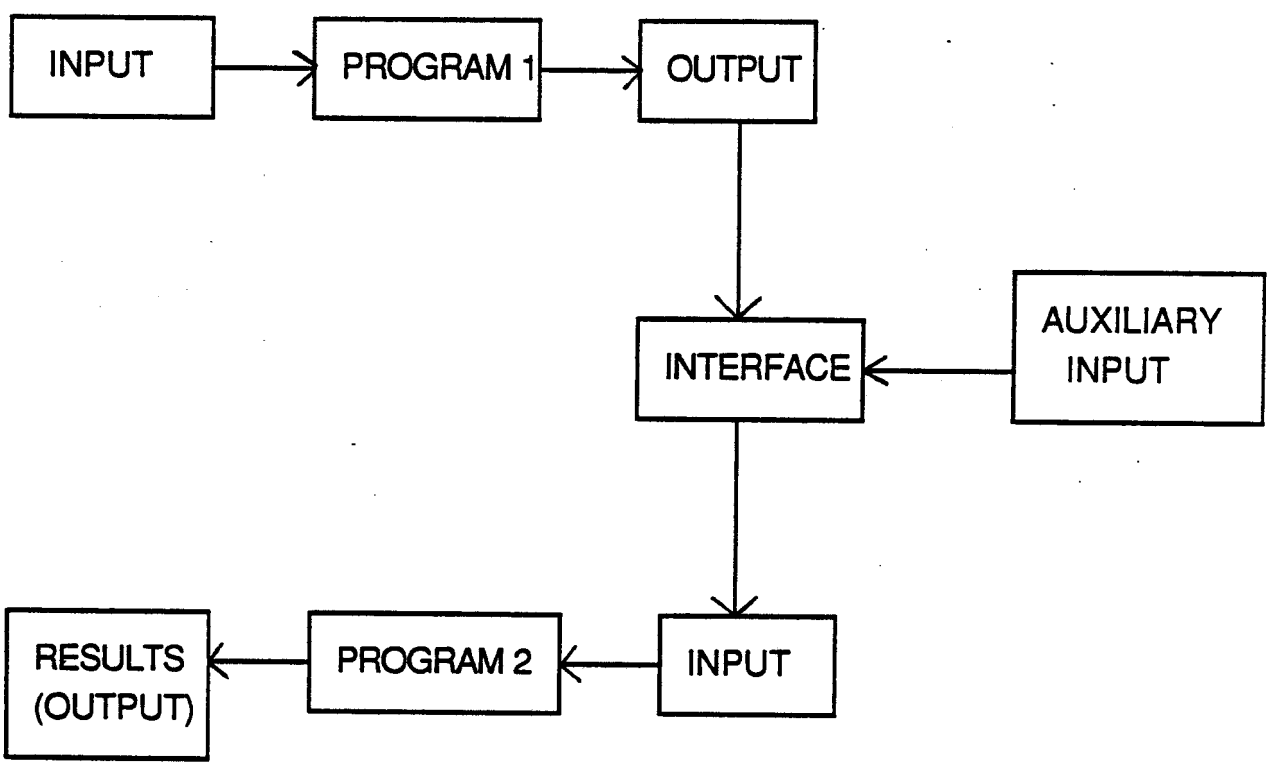

Figure 2.1 Concept of an Interface

If an interface is developed between a CAD system and an energy analysis program, then the user can use such an integrated system as an analytical design tool. The user can design and draft his building using the CAD system. During the design process, at different steps, he can use the interface to get the energy analysis. Using these results the design can be improved to get the allowable energy consumption. The process can be repeated until the user is satisfied with his design. Such an integrated system

can be a useful tool in design studios. It can be called a step towards Computer-Aided-Design in architecture, which we consider to be different from Computer-Aided Drafting. Figure 2.2 illustrates this concept.

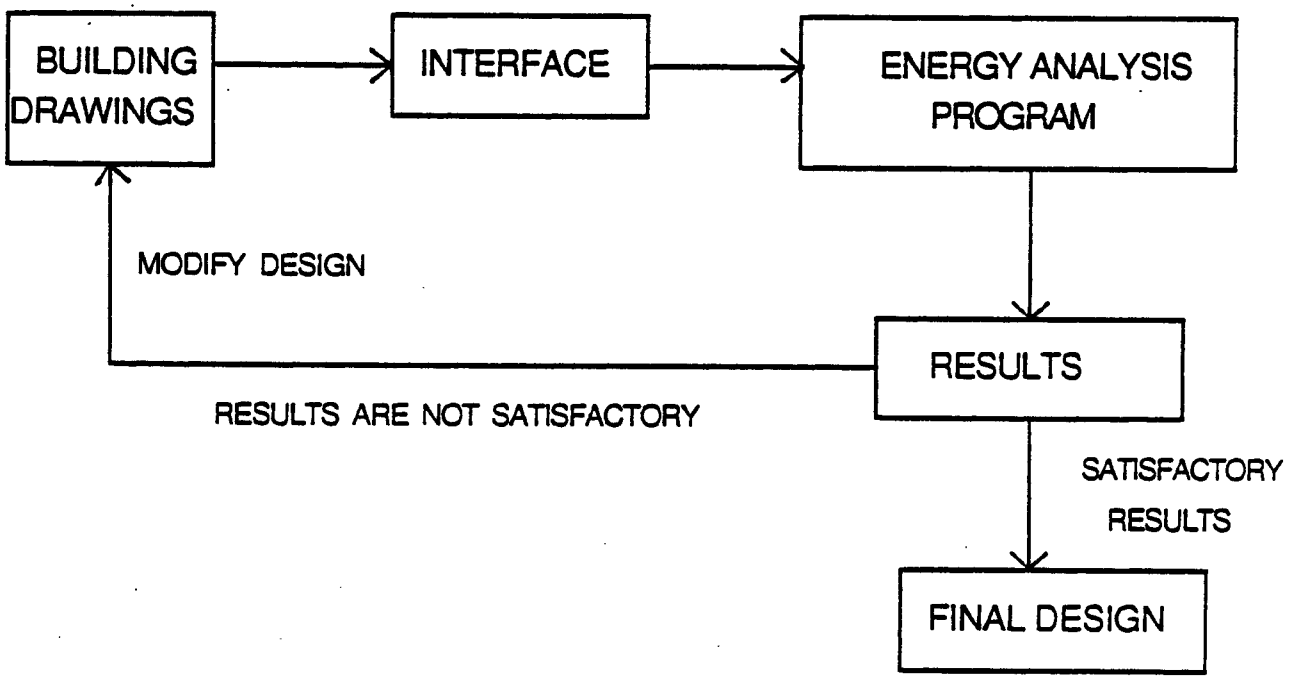

Figure 2.2

3 PROJECT METHODOLOGY

The goal of this project was to develop an interface between a Computer-Aided Drafting System and an Energy Analysis program. Here onwards we will refer to this interface as *"Interface"*.

The first consideration in this project was regarding the choice of a Computer-Aided Drafting System. As AutoCAD is one of the most widely used graphics packages by the architects in the United States, it was chosen as the drafting tool in this project. The second consideration was about the selection of the energy analysis program. CALPAS3 is a popular energy analysis program[2]. Educational CALPAS3 software is very inexpensive. The PC version of CALPAS3 is available since November 1984. So it is one of the suitable packages to be used in design studios. CALPAS3 is designed to analyze the energy performance of residential and small commercial buildings. CALPAS3 was, therefore, selected as the energy program to be interfaced with AutoCAD. The conceptual Design is given in figure 3.1.

It was observed that CALPAS3 gives monthly, daily, hourly summaries, however it takes a long time to run. If the whole system is to be used as an analytical design tool, then it is essential that the energy programs should produce quick results. It does not matter, if it gives approximate results at the preliminary design stage, as long as it gives

a fairly good idea to modify the design. Also it is interesting if such an intermediate analysis is graphical. Later, at the final design stage accurate energy analysis can be done.

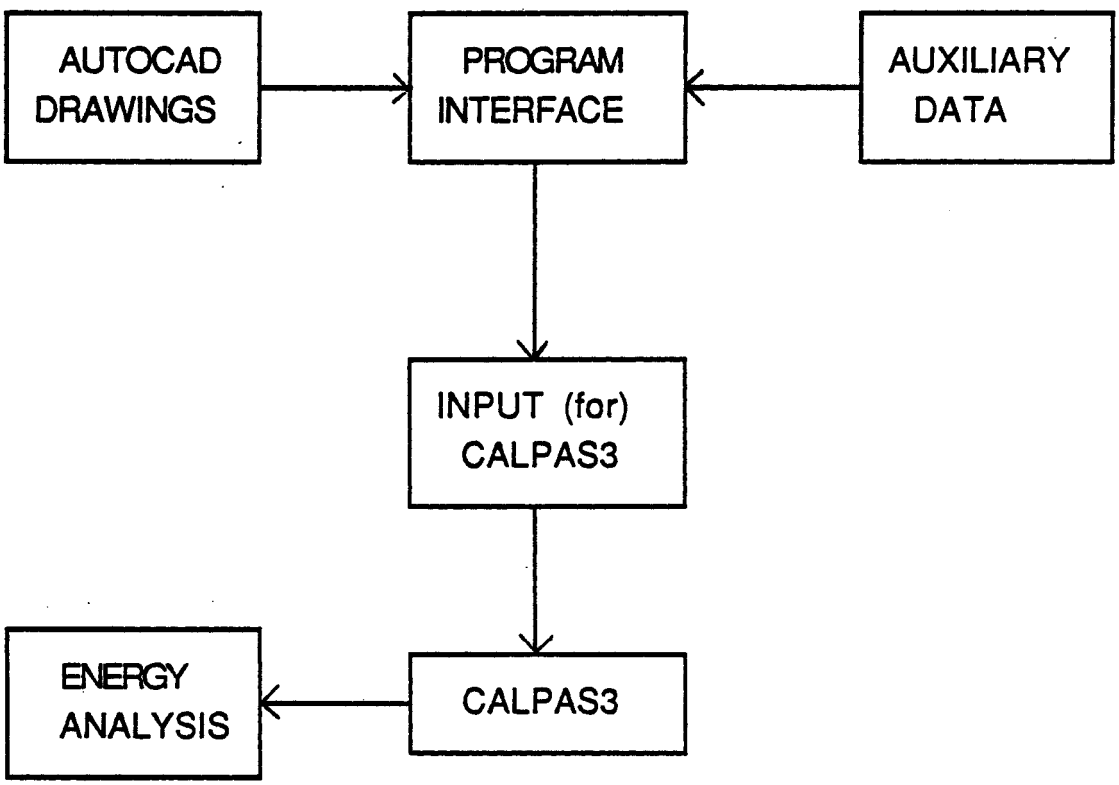

Figure 3.1

"Energy Graphics"[3] can serve the purpose of giving an approximate but quick and graphical output. "Energy Graphics" was prepared as a tool to assist Federal Personnel in designing efficient Federal buildings. This is designed to meet both the new Building Performance Standards and 45% Presidential Energy Reduction goals required by Executive order 120003[3]. The program "Energy Look", written in UCSD Pascal is based on Energy Graphics[4].

Figure 3.2 illustrates the conceptual design of *"Interface"* at this stage.

The user can choose either level 1 or level 2. At level 1 the user can get a quick, graphical energy analysis using "Energy Graphics". While designing, using this level, approximate energy analysis can be obtained at different stages. The graphical output can give a good idea of how to modify the design accordingly. At the final design stage, the level 2 of *"Interface"* can be used to get detailed energy analysis. At this level CALPAS3 is used as the energy analysis tool.

CALPAS3 can produce monthly, daily and hourly reports of energy performance. They are about house energy balance, conditions, sunspace energy balance and rockbed en-

ergy balance. One can also get hourly temperature reports. Solar gain reports are about walls and glass. By specifying energy prices and equipment operating efficiencies the user can get annual operating cost report. Where as Energy Graphics can produce graphs showing internal heat gain, solar heat gain, envelope heat gain and loss, ventilation heat gain and loss. It also produces a graph of total heat gain and loss. These graphs are for four seasons namely winter, spring, summer and fall. The user can also get a very approximate energy cost analysis. From these graphs the user get an idea to improve the design at the sketch design stage.

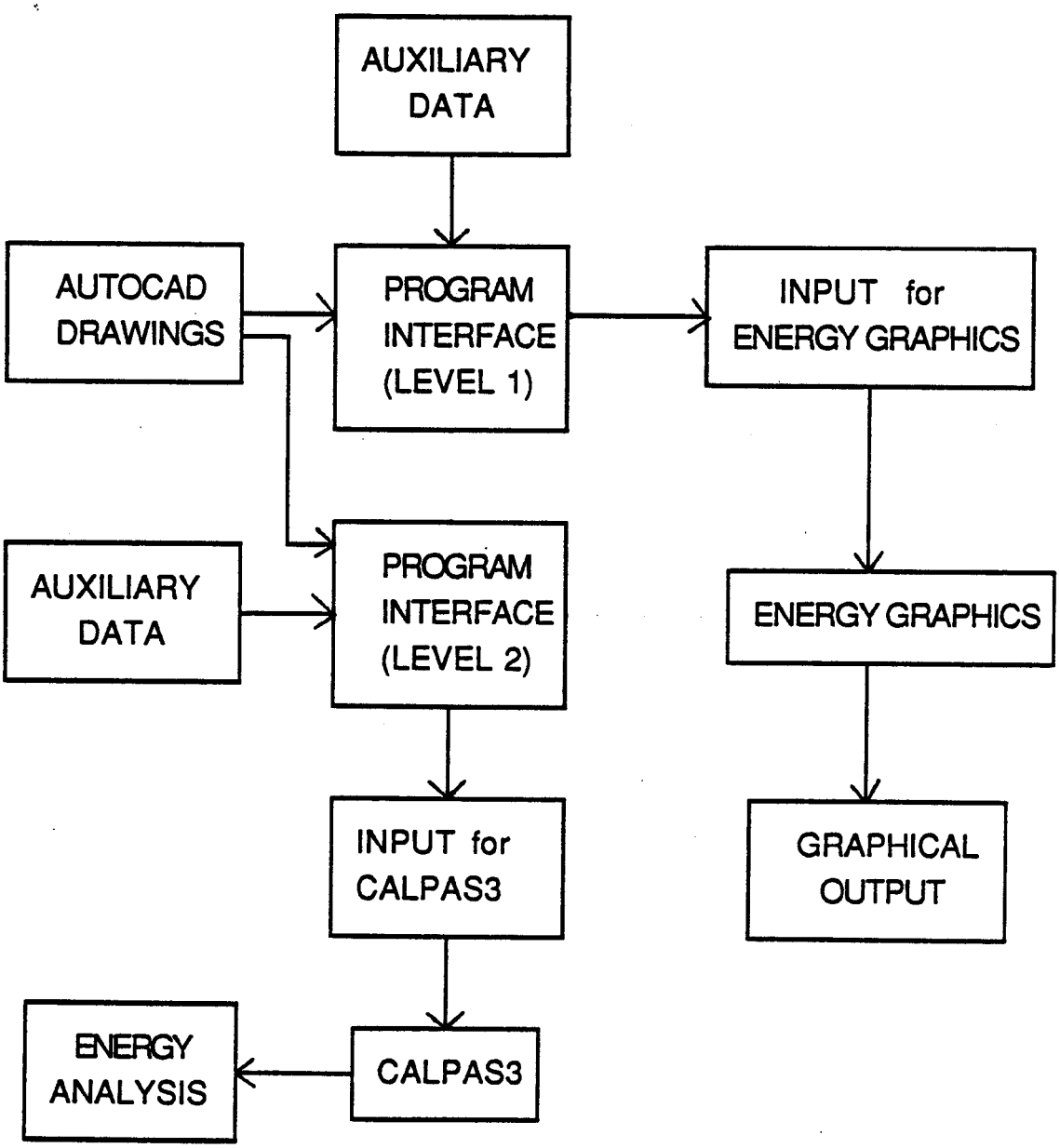

Figure 3.2

4 *"Interface"* : A Brief Description

"Interface" was developed in Turbo Pascal on an IBM PC AT running the DOS operating system. The IBM PC AT was chosen as it is widely used in architectural firms and colleges.

The basic concept in *"Interface"* is to extract information from the drawings drawn using AutoCAD and use this information to form an input file for energy analysis programs. Information which is necessary and not given in the drawings is obtained interactively from the user.

The program *"Interface"* is flexible. Even if the user has no AutoCAD drawings, he can still use *"Interface"* to get energy analysis. Thus he does not need to know the CALPAS3 input syntax. In such a case *"Interface"* gets all the information that is needed to form the input file for the energy analysis program, interactively from the user.

The program is divided into four modules. They are as follows :

1. Decoration,
2. User Interface and Warning Messages,
3. Extraction of Information from the AutoCAD Drawings and
4. Use of Extracted Information to Create New Information.

We now present a brief discussion of all the four modules.

1. Decoration : This module displays the information about the program on the screen.

2. User Interface and Warning Messages : All the necessary information to form the input for the energy analysis programs may not be obtained from the drawing files. The information that is not extracted from the drawing files can be obtained from the user interactively. This module is *User Interface.*

If the system is used as a designing tool, then the user may use it for a particular design repetitively as he modifies the design. There is a set of information which is the same for a design, irrespective of the modifications in the initial design. Examples of such information are the latitude of the site, the altitude of the site, the beginning and end hours of the day in different seasons. *"Interface"* creates a file of such information first time the user uses it. And then for the next iterations it avoids asking the user for this information and instead fetches it from the already created file.

CALPAS3 provides different tables of information to the user to input his data. *"Interface"* displays these tables whenever needed as a menu on the screen. A choice is given to the user to enter information if it is different from the standard information given in the menu.

It is assumed that the system will be used by the students in the design studios or by naive users. Hence, efforts have been made to provide possible error checks.

CALPAS3 can give monthly, daily, and hourly reports of energy consumption. But then, it takes a longer time to run. Many users may not need all this information. So warnings messages are given to go for those sections, only if the user wants them.

3. Extraction of Information from AutoCAD : Software Arts, Inc. has provided the *Data Interchange Format(DIF).* Many software packages such as VisiCalc, Lotus 1-2-3

use the *DIF* format. This assists in interchanging data between different programs on different systems. AutoCAD provides a *Drawing Interchange File Format(DXF* format). *DXF* files are standard ASCII files.

Using the AutoCAD command "DXFOUT", all the drawing files are converted into the Drawing Interchange File format before using *"Interface"*. *"Interface"* extracts the necessary information from these files.

By using AutoCAD *Attributes* instead of *Drawing Interchange File Format* this module can be made more flexible and simpler.

4. Use of Extracted Information to Create New Information : From the Drawing files basic information about the building is extracted. Using this information certain calculations are carried out. For example, a plan is considered as a polygon. From the drawing files the X and Y coordinates of the corners of this polygon are extracted. These coordinates are used to calculate the area of the plan. The polygon can be a concave one or a convex one. Circular plans are optimized as polygons with several sides.

5 SUMMARY

This paper presents an idea of an interface between a CAD system and an Energy Analysis Simulation System. The idea is not new. It also describes an interface developed between AutoCAD and CALPAS3 which are popular packages.

The integrated system can be used as a designing tool in design studios. Usage of the system can help avoid wrong assumptions in the early design stage. It can also help to give directions to generate alternative architectural design solutions or to select a best alternative to go to design development. At the final design stage, it can give a detailed energy analysis. The program is not an expert system which can advise the user about future directives but the user can get a good idea about the energy performance of a building. The system can be considered as one of the applications in the area of Computer-Aided Design in architecture.

6 REFERENCES

1. AUTOCAD Reference Manual, AutoDesk Inc., Sausalito, Ca., 1986.

2. CALPAS3 User Manual, Berkeley Solar Group, Berkeley, Ca., 1984.

3. Booz, Allen & Hamilton Inc., "Energy Analysis, A New Approach to Energy Conscious Design", U.S. Department of Energy, NTTS Publication Number DOE-CS-0171, 1980.

4. Bovill Carl, "UCSD Pascal Intrinsic Units Used to Create a File Driven Early Design Energy Analysis Program With Input Error Checking Automatically Provided By The UCSD Pascal Compiler", *Proceedings of The First National Conference On Microcomputer Applications For Conservation And Renewable Energy,* University of Arizona, Tucson, 1985.