Ph.D. Synopsis

Subject: Computer Science

1. Name of the Research Student : Mrs. Rajani S. Kamath

   Qualification : M.Sc. Computer software

   Address : Flat No – 2
   Siddivinayak Appts
   Tarabai Park
   Kolhapur – 416 003

2. Name of the research Guide : Dr. R.K. Kamat

   Qualifications : M.Sc., Ph.D.
   (Electronics)

   Address : Reader
   Department of Electronics
   Shivaji University,
   Kolhapur – 416 004

3. Title of the proposed Thesis : An Optimization Algorithm for Visualization of Object

4. Introduction:

Scientists in many disciplines use sophisticated computer techniques to model complex events and visualize phenomena that cannot be observed directly. Weather patterns, medical conditions, mechanical assembly and mathematical relationships are only some of the uses to which virtual reality can be put to. Some of the main applications of computer based visualization techniques are shown in figure 1.

In case of the mechanical industry, advantages of the computer based visualization techniques are more realized. These techniques are especially useful for developing high-performance mechanical and electro-mechanical products. They allow acquisition of important information that can aid the designer in correcting and controlling the product right from the early conceptualization to the final assembly design stage. In order to improve efficiency and reduce the product weight and volume, designers need to pack a large number of components in a very small space. At the same time, in order to make products easier to assemble and service, designers need to leave enough room for performing assembly and disassembly operations. These requirements are quite often in conflict and make design of electro-mechanical products a highly iterative process. In the absence of high fidelity visualization techniques most product development teams are forced to include physical prototyping in the design loop to verify proper functioning and ease of assembly. Physical prototyping is a major bottleneck in rapid product design and results into more time to market. It slows down the product development process and seriously constrains the number of design alternatives that can be examined. Furthermore, after a prototype has been built and tested, a significant amount of

time is spent in creating instructions for performing assembly and service

A result of past technology limitations, conventional 2D-based design has a certain inherent inefficiency. Historically, practical time considerations aided by reasonably uncomplicated design requirements yielded a design process wherein the designer converted a 3D mental image into abstract 2D representations. Understanding the designs requires the reverse learned skill of transforming the 2D model to a mental 3D image. Add to this process the complication of coordinating numerous 2D-based designs, and the opportunities for errors in design communication become apparent.

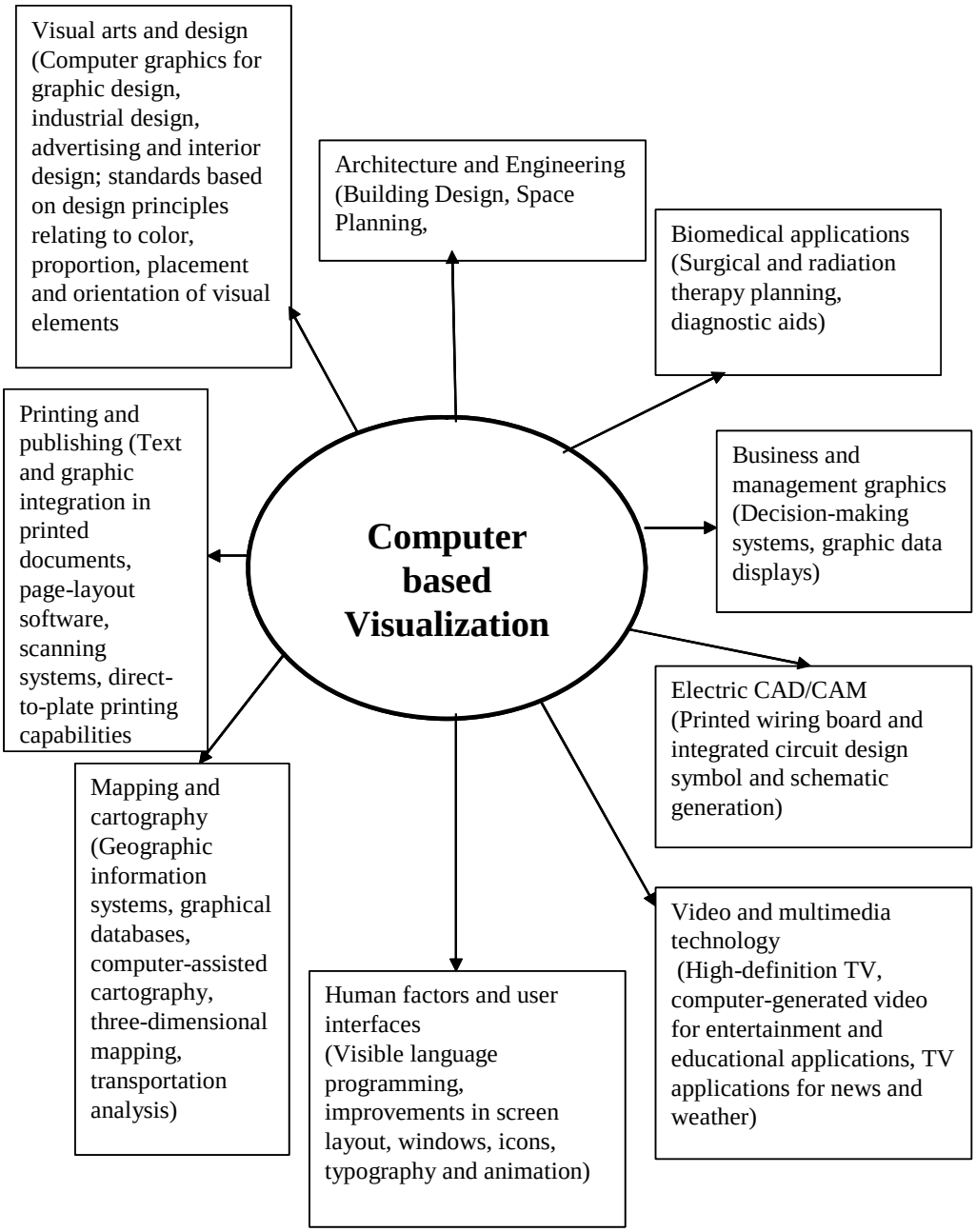

Figure 1: Current uses of Computer visualization techniques

Since the present research proposal pertains to development of visualization platform for mechanical industries, it is worthwhile to see some of the advantages in this context. By rapidly simulating the performance of mechanical systems on the computer, functional virtual prototyping enables to troubleshoot problems within existing designs and to significantly reduce the risk associated with developing new designs.

By facilitating collaborative decision-making and inter departmental communication, the Virtual Reality visualization solutions enable teams to identify and resolve design and manufacturing problems earlier. By making the right decisions based on digital data, companies can optimize their designs and reduce the number of physical prototypes built, thus saving both time and money. In the course of this work we are developing a cost effective software platform for easy visualization of the mechanical components without much intricacies of the sophisticated computing platform.

5. Research Problem:

Need for the present investigation:

The proposed software will demonstrate how a low end, inexpensive viewing technique can be used as a quick trick to produce many of the same effects as high-end stereo viewing.

With the basic background covered under the introduction part the need of visualization software is already justified. Although such software readily available in the market, they require sophisticated computing platforms that are out of the reach of the small firms and independent designers. It has been observed that

most of the large mechanical industries make heavy use of the modeling software to facilitate a concurrent engineering approach for the product design, 3D modeling, analysis and manufacturing applications. The main reason why the small firms or independent designer find it difficult to compete with the big players is lack of such software. The proposed research work attempts to bridge this gap. It aims at designing a general-purpose software platform for visualization of the mechanical assembly executable on fairly available computer architecture. This makes the proposed software unique, as the state of art software such as Vcollab [1], requires at least a workstation or powerful computers or clusters for their execution. Moreover it is planned to empower the designer with few additional tools not available in the existing software. This can be achieved by adopting a new methodology described in the following paragraph.

It is observed that the 3D models generated using the state of art modeling software leads to very heavy file size. This is due to the fact that the modeler not only holds the geometric information, but also topological information of the object. Therefore it requires a powerful computer system to view the components. Moreover, these software tools lack few essential features such as texture mapping, background and base selection, applying user defined material and light, walkthrough etc. Since the file contains data sets, which are not required for visualization, manipulating such files solely for visualizing stereo mode results in slow operation on a general-purpose computer. The approach adopted in the research work is to manipulate the ASCII format files exported by any modeling software. The above-mentioned ASCII file contains dataset that is required for visualization. These less bulky ASCII files will be manipulated by the proposed software by considering only the required data sets for visualization in order to obtain the desired displays.

Details of the proposed implementation:

This software will demonstrate visualization of various components related to mechanical industry. This will be done by developing a module to parse through the files generated by modeling software to render the respective component. It is planned to enhance the effectiveness by facilitating the toolbox supporting the following additional features:

- applying various lights,
- applying material color,
- options for solid, wire frame, points, lines,
- transparency viewing,
- texture mapping,
- applying fog effect,
- walkthrough,
- getting cut section,
- different background color selection for effective contrast,
- mark up features,
- different camera views,
- copying the rendered object to the clipboard and enabling to view more than one model through either tiling or cascading the windows.

It is planned to use OpenGL tool for rendering the mechanical components. These objects are described as sequences of vertices or pixels. OpenGL will be used to perform several processing steps on this data to covert it into a form of the final desired image. Standard OpenGL features will be used to create both statically and interactive interfaces.

6. Significance of research work:

The key theme of the proposed software is parsing the ASCII files generated by any modeling software and to render the corresponding image. Even though this file contains huge details about the model, the proposed software will fetch only the data, which is required for visualization. This will lead to faster execution as contrasted with the existing softwares manipulating the entire file for visualization.

The primary goal of the research work is to empower the designers with a fully functional stereovision facilitating them that to explore their datasets in a graphical manner. This will realize the collaborative decision-making and interdepartmental communication. The software visualization solutions enable the design teams to identify and resolve design and manufacturing problems earlier. Further by making the right decisions based on digital data, companies can optimize their designs and reduce the number of physical prototypes built, thus saving both time and money.

The proposed software would support both active and passive stereo. Active stereo is highly expensive which requires Crystal eye ware, standard emitter, and stereo capable graphics card. Where as passive stereo is a low cost technique, which requires only red blue eye ware. However, the main focus will be to develop an effective low cost passive stereo executing on a fairly general-purpose computer used in day-to-day life.

7. Literature Survey:

The related literature review required for this development is presented here.

Computer techniques have been widely investigated and employed in the design and manufacturing of engineering products in industries. Most commercial CAD/CAM software systems are focused on mechanical parts. However, computer techniques to support creation and fabrication of soft products recently have a strong need in various applications like apparels, toys, jewelry, shoes, glass, furniture, and art. Construction of these objects by computer is quite different from feature-based design or solid modeling in conventional CAD. It emphasizes more on styling, innovation, value-addition, and human-machine interactions, which requires new 3D modeling paradigms[16]. The thought of Virtual Reality has been since 1965, when Ivan Sutherland at MIT, expressed his idea of creating virtual world. Virtual Reality technology is being used in all kinds of different areas. Virtual Reality takes its customers on virtual walkthrough of buildings that does not exist in the reality, making changes as they go [13]. Educators are creating classroom tutorials that exist only within the virtual worlds of their desktop computers. Virtual Reality has been used for medical surgery and also for training doctors to operate using remote devices. Even today an individual at will can go to Disney World; can visit some of the finest museums of the world; or go to various tourist destinations without moving out of the Virtual Reality room. Similarly he can do window shopping in some of the best shopping malls of the world and in near future may even tryout some of the items displayed. In short a person can fulfill substantial portion of his desires through Virtual Reality at almost zero cost and energy.

The Virtual Reality provides the best way for teams of technical and creative professionals to engage in interactive, real-time engineering and design review, data analysis, critical training, presentation, or command-and-control operations. Visualization places a crucial role in Virtual Reality[27]. Visualization is necessary today's arena of mass information generation to provide one way of filtering this volume of data into something manageable. Virtual reality technique provide one way to enabling these visualizations and afford more benefits[36]. Visual data mining technique have proven to be essential in exploratory data analysis[23]. The technology for using virtual prototypes was pioneered and adopted initially by large automotive and aerospace industries. Virtual prototyping is becoming very advanced and may eventually dominate the product development process [3]. The Virtual Reality solutions are critical tools that manufacturing industry to reengineer their product development practices in order to bring new, better-quality products to market faster, at a lower cost, with more options for consumers [12]. It supports the entire product development process, from conceptual modeling to engineering and design review, visualization of complex analysis data, factory floor simulation, training, and review for customers[14]. Visualization includes interfaces for interaction with user. 3D visualization in virtual environments composed of sensors and panel displays[33]. Virtual reality shows to be of use in several domains of manufacturing as a complementary tool to CAD/CAM environment. Design review is one of the very first applications of VR in product design, but assembly/disassembly studies also exist though they require some more specific work[9].

This paper attempts to provide an overview of current market trends in industrial of Virtual reality AND Visual simulation. In a technological world, VR is the "big opportunity" [25]. Engineers

can expect at least to touch and manipulate a virtual part as they design it and probably even walk inside and around a projection of the design in progress. It is the correct man machine interface for all product design process stages. By this possible to have error deduction, time gains and cost reduction. The most accessible visualization technology in large engineering firms is the virtual prototyping software, often used in conjunction with CAD systems and analysis software. Virtual prototypes allow engineers to test their designs on a computer, rather than by building a physical prototype. 3D model is imported from 3D CAD software and displayed using special viewing and interaction equipment, in a process known as design review.

Industrial technology utilizes visualization in applications such as simulations, modeling etc. The impact of high performance rendering and animation software, solid modeling packages, virtual reality and online testing opens a number of doors for visualization. Visualization is the ability to manipulate an object in an imaginary 3D space and create a representation of object from a new viewpoint[26]. The result of scientific visualization has been a colorful 3D image or animation [28].

In order to get the clear-cut advantage in terms of cost and time in validating the product design for Fit Form and Function, the use of computer based tools and methods are essential. The traditional design tools of manufacturing, CAD and CAM, can be significantly extended through Virtual Reality. Using this technique, a complete "walk-through" of a design can be used to give an environment like feel. This will provide an alternative way for traditional iterative process of repeated development of hardware prototypes for experimentation and performance evaluation. Information visualization techniques are useful in software visualization because a common goal is to reduce the complexity of

the data presented to the user. The 3D visualization creates an environment which people can inhabit and explore [34].

Virtual Reality is used for designing, modeling, building of digital prototypes and generation of manufacturing simulations [19]. It is allowing engineers to design machines and engines in real time but in 3-dimensional hologram as if the actual machine is being made and worked upon. Thus engines have been designed, fabricated and optimized in the virtual world without a single nut or bolt fabricated. This design then goes to the machines for manufacturing the machine in the final form. The first step in this process is the building of Computer Aided Design models. These CAD parts are put together to create a simulated assembly process that could eliminate the need for physical prototypes in the design phase. The Virtual Reality software is a graphics assembly modeling simulation package that allows 3D animated, real time manipulation of parts to verify tooling and assembly strategies for building various product assemblies[20]. After designing components this software is used to manipulate, test and verify the assembly process of these components in the virtual space. User can select parts of subassemblies which may move according to kinematics constraints, visualize the part-to-part clearances and fits, and to plan tooling needs[17]. By providing this feedback early in the design process and by facilitating the early integration of the part design and manufacturing teams the assembly module can drastically reduce the time it takes to design engineering components[25].

As the technologies of virtual reality evolve, the applications of VR become literally unlimited. Developing virtual reality applications has traditionally been very expensive due to the high cost of the equipment involved[2]. It is assumed that VR will

reshape the interface between people and information technology by offering new ways for the communication of information, the visualization of processes, and the creative expression of ideas. Visualization software presents many unique challenges to implementers and integrators[11]. Drawing graph is an important visualization technique[24]. Note that a virtual environment can represent any three-dimensional world that is either real or abstract. This includes real systems like buildings, landscapes, underwater shipwrecks, spacecrafts, archaeological excavation sites, human anatomy, sculptures, crime scene reconstructions, solar systems, and so on[18]. Of special interest is the visual and sensual representation of abstract systems like magnetic fields, turbulent flow structures, molecular models, mathematical systems, auditorium acoustics, stock market behavior, population densities, information flows, and any other conceivable system including artistic and creative work of abstract nature. These virtual worlds can be animated, interactive, shared, and can expose behavior and functionality. Software Visualization is a relatively young research area where great progress has been made in developing ideas, representations and tools to aid program comprehension during maintenance and evolution of software[30].

The OpenGL graphics system is a software interface to graphics hardware[6]. OpenGL is a library of graphics routines available on a wide variety of hardware platforms and operating systems. OpenGL was developed by Silicon Graphics incorporated in the year 1992, and was eventually accepted as an industrial standard for hardcore 3D graphics. OpenGL routines are well structured, highly stable, intuitive, and scalable from PCs to Super computers guaranteed to produce consistent visual displays across various platforms. In order to generate rendering of a model the programmer must specify the appropriate sequence of commands

to set up the camera view and modeling transformations, draw the geometry for a model with a required color etc.

The literature survey reveals that researchers have rated stereovision as the most focal issue[15]. Stereoscopic display is an effective way to enhance insight to 3D scientific visualization[10]. The use of 3 dimensions for visualization is a lot newer than the technology required achieving such visual representation. It is a powerful way of representing large and complex data sets [31]. Using 3 dimensions for visualization adds an element of familiarity and realism in to systems[32]. Generation of an accurate 3-D model of the immediate surroundings of the load-haul-dump is accomplished through processing of stereo visual imagery[8]. Stereo visualization is an area, which can greatly benefit from cluster computing due to the parallelizable nature of the rendering task[7]. Visualization technique is to have a method for trading off shape[22]. It is also important to be able to utilize visualization for display of data[29]. Virtual Reality setup helps in visualization of the components, assemblies and the entire engine in 3D and performs walkthrough, flythrough, assembly visualization etc. [21]. Stereovision achieved in terms of active and passive stereo. Active stereo is highly expensive which requires Crystal eye ware, standard emitter, and stereo capable graphics card[24]. Where as passive stereo is a low cost technique, which requires only red blue eye ware[35].

Immerse Visualization of Virtual Prototypes will give an opportunity to experiment with innovative design variations, gain greater insight earlier in the development cycle, make quantifiable improvements, and make sure that products will work as intended before investing a significant amount of time and money for creating physical systems. By rapidly simulating the performance of mechanical systems on the computer, functional virtual prototyping

enables to troubleshoot problems within existing designs and to significantly reduce the risk associated with developing new designs.

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8. Objectives:

The primary objective of the proposed research work is development of a low cost software platform for visualization of mechanical industry components with stereo support.

The proposed development has following subsidiary objectives:

- Developing a module to parse the files generated by any modeling software and to render the respective component
- Supporting 'Stereovision Capability' with active and passive stereo
- Developing 'Transformation' options like rotation, translation and zooming
- Displaying the object's different modes namely solid, wire frame, line, point and transparent
- Facilitating various views of an object namely front, back, left, right, top, bottom, isometric
- Providing 'Walk through' the object with viewer being at the place itself, only the object is made to come closer or go away
- Developing a module for generation of cutting view of the object along XY-plane, XZ-plane and YZ-plane or with any angle
- Facility to view more than one object simultaneously
- Selection of required materials and lightings

9. Methodology:

The methodology of implementing the proposed system is divided into the following steps:

- **Planning:** During this step software requirement specification will be prepared. The functionalities of different visualization software will be studied in this step. General architecture of the proposed research will be planned on paper.

- **Exploring:** During the explore step, the ASCII files generated by various modeling software will be analyzed. Design flow diagrams for simplifying logic will be generated. The software for implementation of the logic diagram will be chosen.

- **Coding:** During this step the actual programming will be done. At first the parser module for rendering the model on the screen by reading ASCII files generated by modeling software will be completed. Coding will be continued for incorporating other features which are specified in objectives.

- **Testing:** In the testing step the software will be tested with the files generated by modeling software. All the features related to model display will be tested in this phase. The Stereovision capability will also be tested with the help of external interface.

- **Installation:** The finished product will be actually tested by installing it in a mechanical industry.

- **Documentation**: During this step the documentation will be written in the form of manual as well as thesis. The documentation will comprise of the listing of the entire code as well as other information related to software development phases.

10. Time schedule:

Time Schedule:

Task	Year 1				Year 2				Year 3			
	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12
Literature survey	◄►											
Planning	◄►											
Designing Data flow diagrams and flow chart		◄►	◄►									
Analysing the files generated by modelling software		◄►	◄►									
Finalizing the architecture				◄►								
Procuring the software tools					◄►							
Developing parser for ASCII files to render component						◄►						
Adding stereo vision capability							◄►					
designing codes to achive various propertis of model display							◄►	◄►				
Testing the display of component on the screen						◄►						
Testing the stereovision capability With external hardware							◄►					
Conducting testing to check all additional features								◄►				
Installing the software in mechanical industry and tested.									◄►			
Documentation, thesis writing etc										◄►	►	

Mrs. Rajani S. Kamath
Student

Dr. R.K. Kamat
Guide

Coordinator, Dept of Computer science
Shivaji University
Kolhapur