The ***CREDO Laboratory*** (Clemson's Research in Engineering Design and Optimization) performs research targeted to two main areas in the product realization process, namely: design methodology/optimization and rapid and virtual prototyping (Solid Freeform Fabrication and virtual reality for design.)

(1) DESIGN METHODOLOGY and AUTOMATION

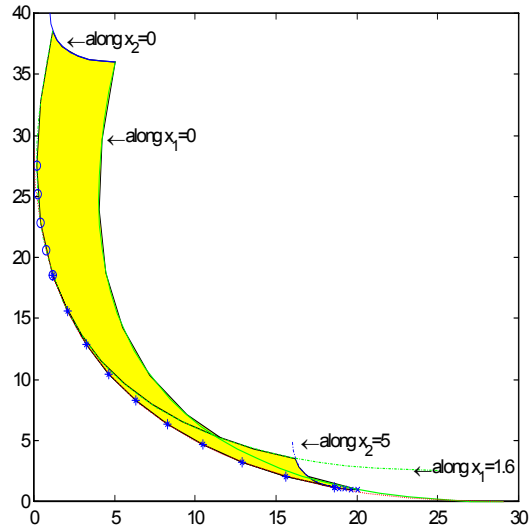
- Study the design process from early conception to pre-production. Investigate ways to represent a design through *form/function* relationships. Study how to represent *affordability* issues early in the design. Develop *metrics* for design. These topics include work on *decomposition* methodologies, form and function structures and evaluation methods such as the *multi-attribute utility* function.

- Investigate and develop a robust concept exploration method for configuring complex engineering systems. Introduce quality concepts into the early stages of design to improve the efficiency and effectiveness of the process of design itself and ultimately the industrial productivity in designing large-scale complex systems. This research involves robust design, axiomatic design, modeling uncertainty, decision support, multidisciplinary optimization, integrated product and process design, and designing open engineering systems.

- Develop methodologies to deal with complex *multidisciplinary or multi-objective problems* such as the *underhood packaging* problem. Generate methods to deal with complex non-convex three-dimensional objects in CAD space and use optimization algorithms that can achieve Pareto solutions in a reasonable time. This work couples CAD systems with genetic algorithms and approximations.

- Develop mathematical *approximation techniques* that improve the efficiency of traditional structural optimization methods while providing key parameters that carry information about the relations describing a design process.

- *Multidisciplinary optimization* - Identify cross-disciplinary links that must be considered when concurrent design is performed. Develop methods for the description and for the evaluation of sensitivities. Investigate the use of genetic algorithms, neural networks, simulated annealing techniques and fuzzy sets in the design process.



Pareto Space of a Bi-objective Problem

- Study mixed discrete-continuous realistic optimization problems. Investigate and develop methodologies to deal with such issues that occur in design applications such as *configuration design*.

- *Collaborative Design* – Investigate and develop methodologies to help design teams work across the boundaries of space and time. Use Net based tools and eventually VR based tools to facilitate the synchronous and asynchronous collaboration. Investigate the development of a model of the information flow in the collaborative design process for support of the development of agent based design aid tools.

- *Creativity in Design* – Investigate issues of creativity in design in search of systematic techniques for selection of idea generation for specific design problems and scenarios. Investigate issues of representation in idea generation (textual, graphical, verbal, gestural).

(2) SOLID FREEFORM FABRICATION - CAD - VIRTUAL REALITY

- Study the *computer aided design (CAD)* issues related to solid freeform fabrication and develop algorithms to improve the accuracy and speed of use of *rapid prototyping systems*.

- Investigate and develop *virtual prototyping* techniques and methodologies aimed at reducing the design cycle time using advanced visualization and simulation tools.

- Determine the shortcomings of current CAD systems for design and develop techniques to address and resolve these issues (involves solid modeling, optimization and expert systems). Explore the use of VR as a truly 3D CAD modeler. Explore issues of *representational view transformations* between domain and platform specifications.

- Develop interfaces between virtual reality (VR) and rapid prototyping and use the VR environment to assist in the design process. Develop also capabilities and methodologies to use *future virtual collaborative design* tools (Virtual Workbench).

- Expand *virtual reality* tools to investigate assembly and maintainability in design.

- Investigate and implement software methodologies and processes to enable *functional prototypes generation* from current and future solid freeform fabrication processes. Both the research areas are currently brought together in the development of design methodologies for multi-material objects:

- Develop the methodologies necessary to design *multi-material objects* in rapid prototyping. This includes data formats for representing volumetric entities, inverse problems, design optimization, multi-criteria optimization.

- Investigation of the requirements of a *CAD query language* for manipulation of CAD file sets and internal CAD data. Extension of constraint problem solving techniques for geometric, topologic, numeric, semantic constraints and solvers. Development of function and behavior entities and constraints for integration with traditional CAD modeling techniques.

☆ *HARDWARE*

Computers:
- SUNs (IPC, IPX, 20, Ultras)
- SGIs (Indys, O2, Reality Engines)
- PCs, Macs

Rapid Prototyping Equipment:
- SLA 250 (3D Systems)
- Sanders Modelmaker
- Selective Laser Sintering machine

Collaborative Design Environment
- Pictel Video Conferencing Package
- PenTablet multi-media PC
- Smartboard collaborative capture
- Virtual Reality Immersive Workbench

Other Equipment:
- Brown and Sharp Coordinate Measurement Machine (CMM)
- Taylor Hobson Profilometer

☆ *SOFTWARE*

CAD Systems:
- Autocad
- BRL- CAD (Ballistic Research Labs)
- PTC Pro-Engineer.
- Unigraphics - I-DEAS
- ACIS 7.0
- DCM
- Think3

Analysis Systems
- Ansys
- Abaqus
- ASTROS
- OPTISTRUCT

Optimization and Design Programs
- DOT (constrained, Non-Linear)
- CONMIN (Constrained NL)
- DSIDES (Multidisciplinary)
- GALib (Genetic Algorithm)
- OPTIMUS (robust design simulation)
- CADShell (CAD Development Environment)
- ISIGHT

☆ *COURSES:*
- Fundamentals of Mechanical and Manufacturing Systems (ME202)
- Numerical Analysis for Engineers (ME205)
- Computer Aided Engineering and Design (ME 471/671)
- Advanced Engineering Design I: Design Methodologies (ME841)
- Advanced Engineering Design II: Engineering Optimization (ME 842)
- Special Topics in Design: Computational and Statistical Methods or Design (ME 893)
- Special Topics in Design: Research Issues in Collaborative Engineering Design (ME 893)
- Special Topics in Design: CAD Tools for Mechanical Engineers (ME 893)

☆ *ALUMNI AT:*

Ford, Altair, Abaqus (HKS), Siemens SDRC, Unigraphics, Dassault, Bentley, EOS, Fluent, Pratt & Whitney, Motorola

☆ *FACULTY:*

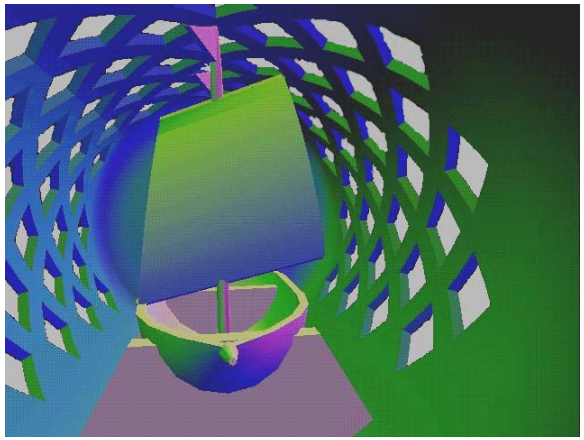
Georges Fadel, Professor
Tel: (864) 656-5620
Fax: (864) 656-4435
georges.fadel@ces.clemson.edu

Joshua D. Summers, Assistant Professor
Tel: (864) 656-3295
Fax: (864) 656-4435
joshua.summers@ces.clemson.edu

For Additional Information
http://www.vr.clemson.edu/credo/

Clemson's Research in Engineering Design and Optimization

LABORATORY



•

Fluor Daniel
Engineering Innovation Building
Mechanical Engineering Department
Center for Advanced Manufacturing
Clemson University

Clemson, SC 29634-0921