

## 24-688: Introduction to CAD/CAE Tools

@ HH-B103 (Lecture)

@ BH 140E (Computer Cluster Sessions)

<http://www.andrew.cmu.edu/course/24-688/>

# Digital Engineering Courses

24-688: Introduction to CAD / CAE Tools

24-780: Engineering Computation

24-681: Computer-Aided Design

24-682: Computer-Aided Engineering

**24-688: Introduction to CAD/CAE Tools**  
Carnegie Mellon University

**Lectures:** Thu 8:50 AM - 10:20 AM @ BH 0103  
**Computer Cluster Hours:** Tue and Thu, one-hour session between 10:30AM and 1:30PM  
**Session 4:** 10:30AM-11:30AM @ BH 1406. **Session 5:** 11:30AM-12:30PM @ BH 1406  
**Session 6:** 12:30PM - 1:30PM @ BH 1406

**Scope of Course:** This course offers the basics on training on how to apply modern CAD and CAE software tools to engineering design, analysis and manufacturing. In the first section, students will learn through 5 hands-on projects how to model complex free-form 3D objects using commercial CAD tools. In the second section, students will learn through 5 hands-on projects how to simulate complex mechanical phenomena using commercial CAE tools. [\(Go back to course details\)](#)

**Level:** introductory graduate course  
**Units:** 12  
**Format:** Every week, we will have a 2-hour lecture on Tue and Thu, 1.5-hour computer cluster sessions on Tue and Thu. **Prerequisite:** Basic knowledge about solid mechanics, fluid dynamics, and heat transfer.

**Learning Objectives:** After taking this course, students should be able to perform the following tasks using modern CAD and CAE software tools:

**CAD**

- Create the 3D model development process
- Express a product design idea using 3D digital sketches
- Model a component with freeform surfaces
- Model an assembly of components with isometric linkages
- Render and animate the appearance and functionality of a product

**CAE**

- Set up material properties, boundary conditions, meshes, and loading condition for engineering analysis
- Perform linear structural analysis
- Perform non-linear structural analysis
- Perform computational fluid dynamics analysis
- Perform multi-physics analysis

**Teaching Staff:**  
**Professor Keri Simola (Instructor)**  
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**Email Lists:** To send a message to all the teaching staff (use this when you ask a technical question):  
cmu-cadcae@lists.soe.cmu.edu  
To send a message to all the students (this is mainly for teaching staff use only):  
me24688@lists.soe.cmu.edu

**24-780: Engineering Computation**  
Carnegie Mellon University

**Lectures:** - Mon and Wednesday 9:50 am - 1:20 pm (Phyton lab 7)  
**Computer Cluster Hours:** - Thursday 8am - 10am (BH-C105) & Saturday 9am - 10am (BH-C105)

**Scope of Course:** This course covers the practical programming and computational tools necessary to engineer. These include programming in C++, and 2D programming in C++ in addition to covering the use of engineering software in analysis and optimization. The course also includes hands-on computer assignments for practice of common operations in the programming languages.

**Learning Objectives:** After taking this course, students should be able to:

- C++ Programming
- Create a program in Microsoft Visual C++ Express
- Apply numerical methods to solve problems in one and two variables with C++
- MATLAB Programming
- Use MATLAB to solve problems in one and two variables with C++
- Analyze and solve problems in one and two variables with MATLAB

**Engineering Computation:** Design and analyze software in a team and implement the team based on computation.

**Teaching Staff:**  
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**24-681: Computer-Aided Design**  
Carnegie Mellon University

**Lectures:** - Tuesday & Thursday 10:00 AM - 11:30 AM (South Hall 214)  
**Computer Cluster Hours:** - Monday 2:00 PM - 4:00 PM @ BH-C105, Tuesday 4:30 PM - 6:00 PM @ BH-C105

**Scope of Course:** This course is the first section of the two semester sequence on computer-aided design. Students will learn how to construct and manipulate 3D models. The course covers the use of engineering design in product models. The course covers the use and application of the manufacturing capabilities. Modeling and simulation of free dimensional geometry used used in the engineering design process. The course is the first section of the course and is a prerequisite for 24-682.

**Learning Objectives:** After taking this course, students should be able to:

- Design Geometry: Represent points, lines, and planes in 3D space
- Parametric design in 2D space
- Represent surfaces in 2D space
- Use parametric design in 3D space

**Mesh Based Modeling:** Represent surfaces and volumes using free-form engineering software. Improve algorithms for representing and processing geometry. Mesh and work in 3D space.

**Curves and Surface Modeling:** Represent surfaces and volumes in 2D space. Formulate and evaluate modeling. Surface and volume curves. Formulate and evaluate free-form surfaces.

**Sub Modeling:** Represent a solid geometry with B-Rep. Represent a solid geometry with CAD. Represent a solid geometry with Free-Form.

**Teaching Staff:**  
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**24-682: Computer-Aided Engineering**  
Carnegie Mellon University

**Lectures:** - Wed and Thu 2:30-3:20 PM (BH-C105)  
**Computer Cluster Hours:** - Fri 2:30 PM - 4:00 PM, Mon 4:30 PM - 6:00 PM, Tue 12:30 PM - 2:00 PM

**Scope of Course:** This course is the second section of the two semester sequence on computer-aided design. Students will learn how to construct and manipulate 3D models. The course covers the use of engineering design in product models. The course covers the use and application of the manufacturing capabilities. Modeling and simulation of free dimensional geometry used used in the engineering design process. The course is the second section of the course and is a prerequisite for 24-681.

**Learning Objectives:** After taking this course, students should be able to:

- Engineering Analysis: Simulate the stress analysis of a part
- Simulate the stress analysis of a part
- Simulate the stress analysis of a part

**Mesh Path Generation:** Simulate the stress analysis of a part. Simulate the stress analysis of a part. Simulate the stress analysis of a part.

**Manufacturing Planning:** Simulate the stress analysis of a part. Simulate the stress analysis of a part. Simulate the stress analysis of a part.

**Optimization:** Simulate the stress analysis of a part. Simulate the stress analysis of a part. Simulate the stress analysis of a part.

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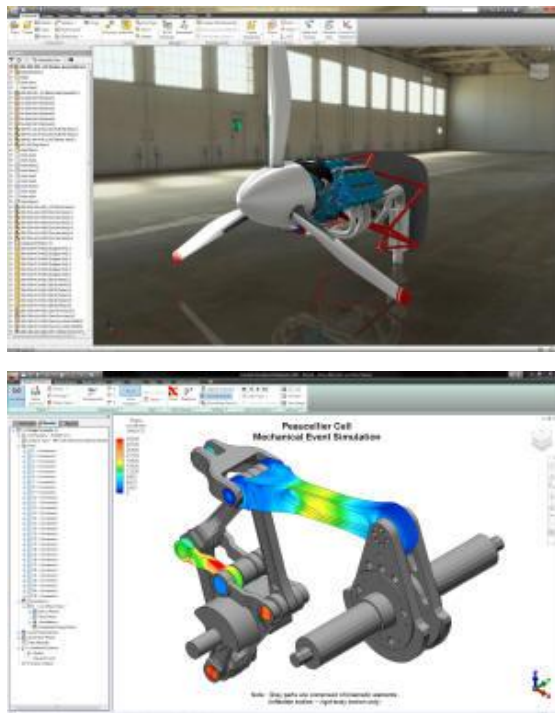
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# 24-688 Introduction to CAD/CAE Tools

This course offers hands-on training on how to apply modern CAD and CAE software tools to engineering design and analysis.

You will learn how to model and simulate complex 3D products using digital engineering tools.



# Learning Objectives

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## CAD

- Describe the product development process
- Express product design ideas using 2D sketches
- Model a component with complex shapes
- Model an assembly of components with kinematic linkages
- Render and animate the appearance and functionality of a product

## CAE

- Perform linear structural analysis
- Perform non-linear structural analysis
- Perform kinematic motion study analysis
- Perform Computational Fluid Dynamics analysis
- Design optimization using simulation

# Course Schedule at a Glance

Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
1 (9/26)		No cluster hours		Lecture 1 (PS1 Out) Cluster Session (CP1)			
2 (9/2)		Cluster Session (CP1)		PS1 Due Lecture 2 (PS2 Out) Cluster Session (CP2)			
3 (9/9)		Cluster Session (CP2)		PS2 Due Lecture 3 (PS3 Out) Cluster Session (CP3)			
4 (9/16)		Quiz 1 (PS1, PS2)		PS3 Due Lecture 4 (PS4 Out) Cluster Session (CP4)	CAD Project Out		
5 (9/23)		Cluster Session (CP4)		PS4 Due Lecture 5 (PS5 Out) Cluster Session (CP5)			
6 (9/30)		Quiz 2 (PS3, PS4)		PS5 Due Lecture 6 (PS6 Out) Cluster Session (CP6)	CAD Project Interim Report Due		
7 (10/7)		Cluster Session (CP6)		PS6 Due Lecture 7 Cluster Session (CP7)			
8 (10/14)		Cluster Session (CP7)		Lecture 8 CAD Project Presentation	Mid-Semester Break	>>>>	>>>>
9 (10/21)		Quiz 3 (PS5, PS6)		Lecture 9 (PS7 Out) Cluster Session (CP9)			
10 (10/28)		Cluster Session (CP9)		PS7 Due Lecture 10 Cluster Session (CP10)	CAE Project Out		
11 (11/4)		Cluster Session (CP10)		PS8 Due Lecture 11 Cluster Session (CP11)			
12 (11/11)		Quiz 4 (PS7, PS8)		PS9 Due Lecture 12 Cluster Session (CP12)			
13 (11/18)		Cluster Session (CP12)		PS10 Due Lecture 13 Cluster Session (CP13)	CAE Project Interim Report Due		
14 (11/25)		Cluster Session (CP13)	>>>>	Thanksgiving Break	>>>>	>>>>	>>>>
15 (12/2)		Quiz 5 (PS9, PS10)		Lecture 14 CAE Project Presentation			

# Grading

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- 11 Problem Sets –  $3\% \times 11 = 33\%$
- 5 Quizzes –  $8\% \times 5 = 40\%$
- CAD Team Project –  $8\%$
- CAE Team Project –  $8\%$
- Class Participation –  $11\%$



# Locations

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## Lectures

- Time: Thursdays 8:30am – 10:20am
- Location: HH B103

## Computer Cluster Sessions

- **Session A**
  - Tuesdays & Thursdays 10:30am – 11:20am
  - Location: BH 140E
- **Session B**
  - Tuesdays & Thursdays 11:30am – 12:20pm
  - Location: BH 140E
- **Session C**
  - Tuesdays & Thursdays 12:30pm – 1:20pm
  - Location: BH 140E

# Software Packages

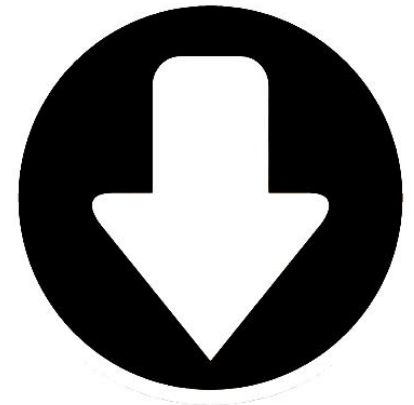
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## Required Software Packages

- Autodesk SketchBook Designer
- **Autodesk Inventor Professional**
- Autodesk Showcase
- **Autodesk Simulation Multiphysics**
- Autodesk Inventor Publisher

Download the packages from:

- <http://students.autodesk.com>





# The Instructor Team

## Professor Kenji Shimada (Instructor)

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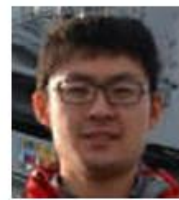
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## Haichao Xu (Tutor / Grader)

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## Vijay Raman (Tutor / Grader)

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## Hakan Kavurt (Tutor / Grader)

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## Nan Gao (Tutor / Grader)

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## Songjie Zhong (Tutor / Grader)

Email: songjie @ andrew.cmu.edu



# Instructor – Prof. Kenji Shimada

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- **28** years of professional experience
  - **14** years at IBM  
(including 4 years of graduate study at MIT,  
Ph.D. in Mechanical Engineering with Business Minor)
  - **16** years at CMU  
(including 9 years of running two technology start-ups)
- Theodore Ahrens Professor in Engineering at Carnegie Mellon University
  - Mechanical Engineering (primary appointment)
  - Robotics Institute
  - Biomedical Engineering
  - Civil and Environmental Engineering
- Director of the Computational Engineering and Robotics Lab.

**"Value compass": Needs x Seeds x Experiences = Values**



**.CERLAB.**

# Computational Engineering & Robotics Lab.

**Kenji Shimada, Ph.D.**

Theodore Ahrens Professor in Engineering

Mechanical Engineering

Robotics Institute

Biomedical Engineering

Civil and Environmental Engineering

**Carnegie Mellon University**

# Engineering

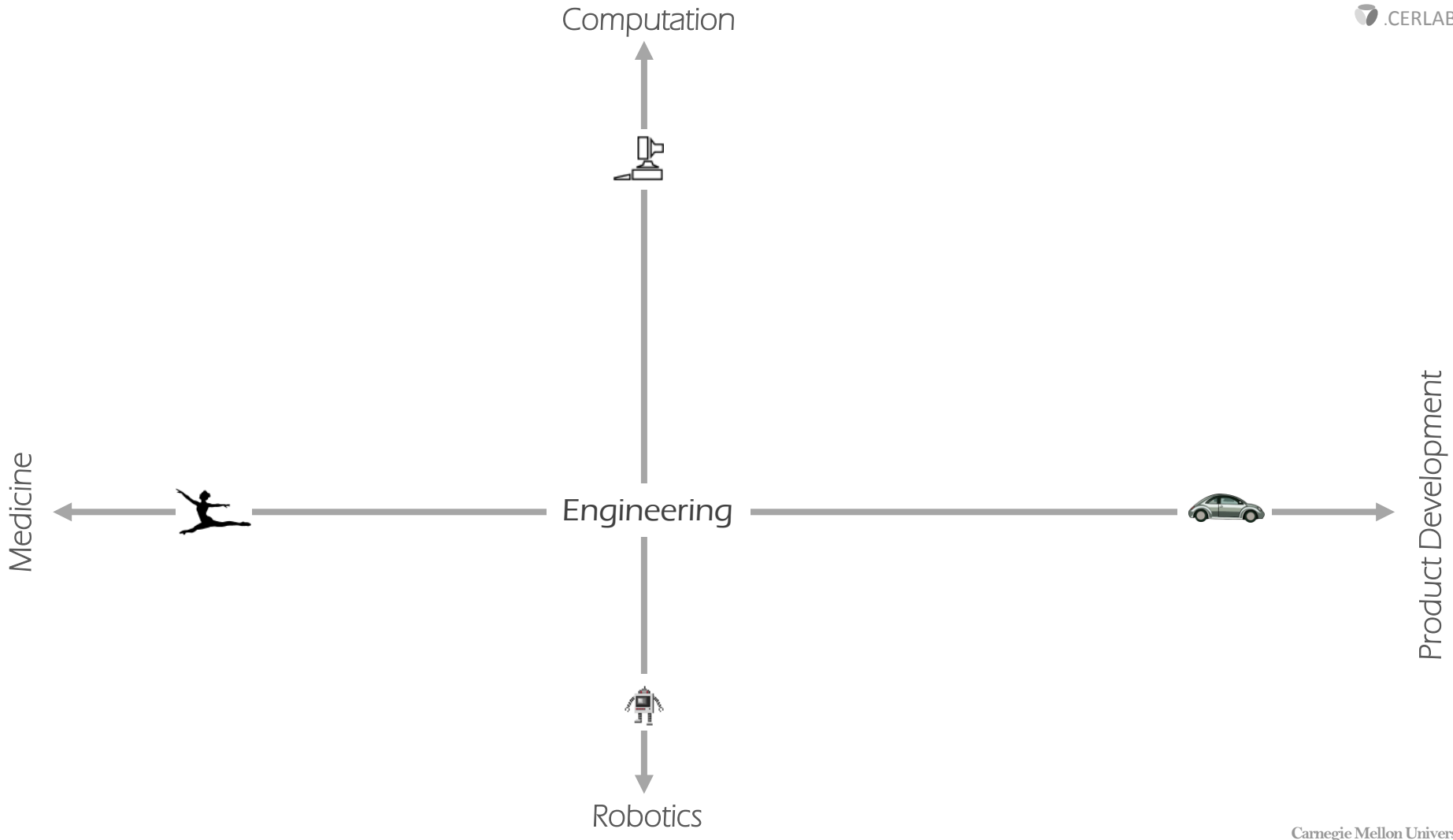
Computation



Engineering



Robotics



# Computation



# Robotics



Sketch CAD for automobile styling design

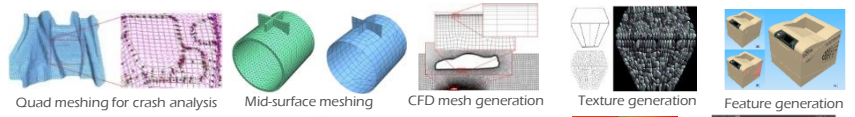
Sketch CAD for automobile seat design



Sketch CAD for industrial design

Segmentation and noise removal from a laser-digitized mesh

Volume decomposition



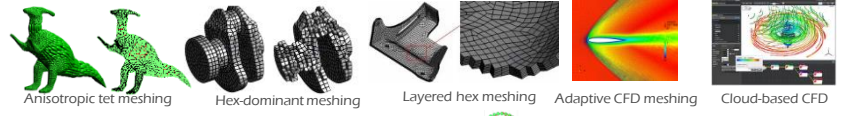
Quad meshing for crash analysis

Mid-surface meshing

CFD mesh generation

Texture generation

Feature generation



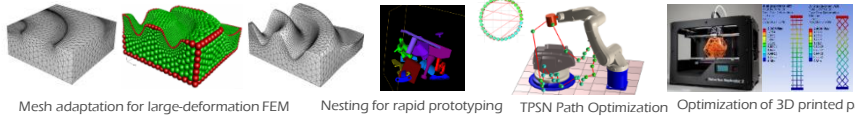
Anisotropic tet meshing

Hex-dominant meshing

Layered hex meshing

Adaptive CFD meshing

Cloud-based CFD



Mesh adaptation for large-deformation FEM

Nesting for rapid prototyping

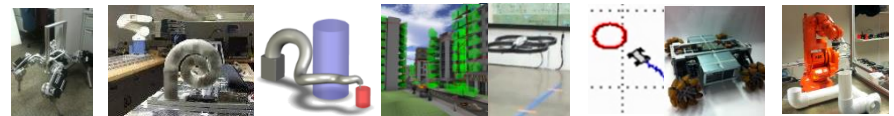
TPSN Path Optimization

Optimization of 3D printed part

# Engineering



# Product Development



12 DOF legged robot

7DOF redundant robotic manipulator

UAV flight path optimization

Machine-learned robot controller

Robotic gluing



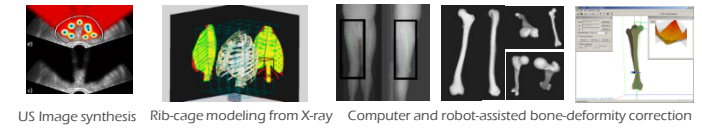
Motion-teaching 3D pen

Gesture-based motion teaching

Laser digitizing for reverse engineering

Optimal path generation

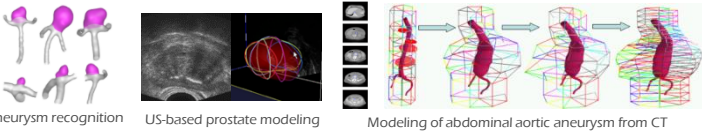
# Medicine



US Image synthesis

Rib-cage modeling from X-ray

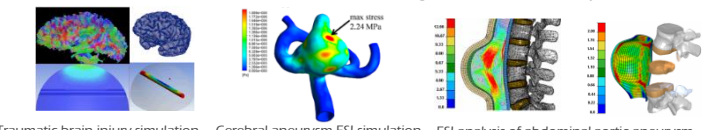
Computer and robot-assisted bone-deformity correction



Aneurysm recognition

US-based prostate modeling

Modeling of abdominal aortic aneurysm from CT



Traumatic brain injury simulation

Cerebral aneurysm FSI simulation

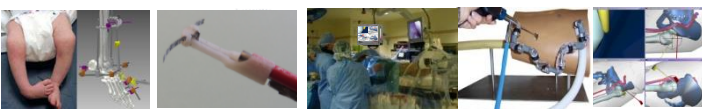
FSI analysis of abdominal aortic aneurysm



Device optimization

Speech emotion recognition

Computer-aide tutor and planner for prostate cryosurgery



Clubfoot correction

Trachea measurement

Image-guided arthroscopic hip surgery with position-tracking



3D US for RCI

AR-assisted intubation

US-guided biopsy

Robot-assisted bone deformity correction

