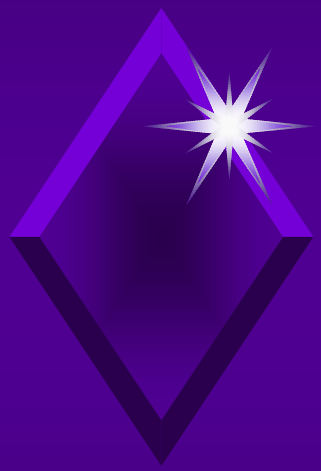

Orthopaedic Surgery Training on Personal Computer

Alexei Sourin, Olga Sourina

Nanyang Technological University, Singapore

Stanislav Klimenko

Moscow Institute of Physics and Technology

Howe Tet Sen

Singapore General Hospital, Singapore

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Background and Objectives

- Singapore General Hospital, Department of Orthopaedics
- Existing training using synthetic bones
- Aim to virtual training using geometric models of the synthetic bones
- Further aim to orthopaedic surgery simulation using geometric models of the bones reconstructed from CT data

System Design

- Virtual Bonesetter
- MS Windows95, Criterion’s Renderware
- Open VR system that includes the following objects:
  - Fractured bones
  - Implants
  - Surgical instruments
- Extendable set of models

Data Source

- Fractured bones
  - Reconstruction from CT data
  - Fracture modelling
- Implants and tools
  - Engineering drawings and data from the medical atlases and booklets
  - Software modelling and interactive design

Plastic Bones

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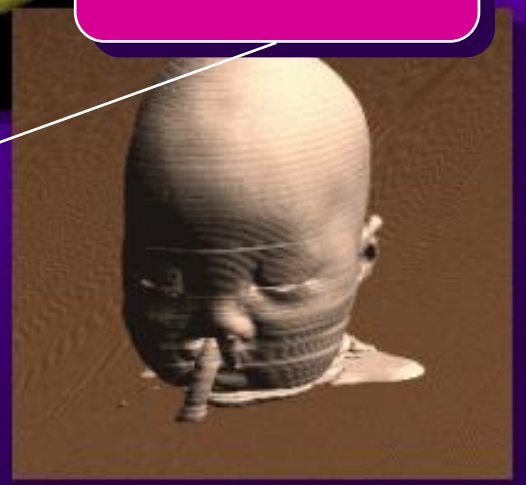
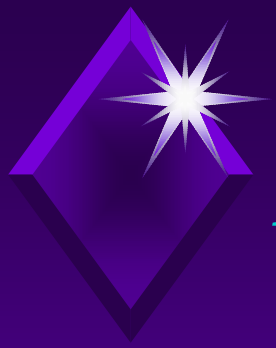
Reconstructed Bones

CT

Reconstruction



RWX



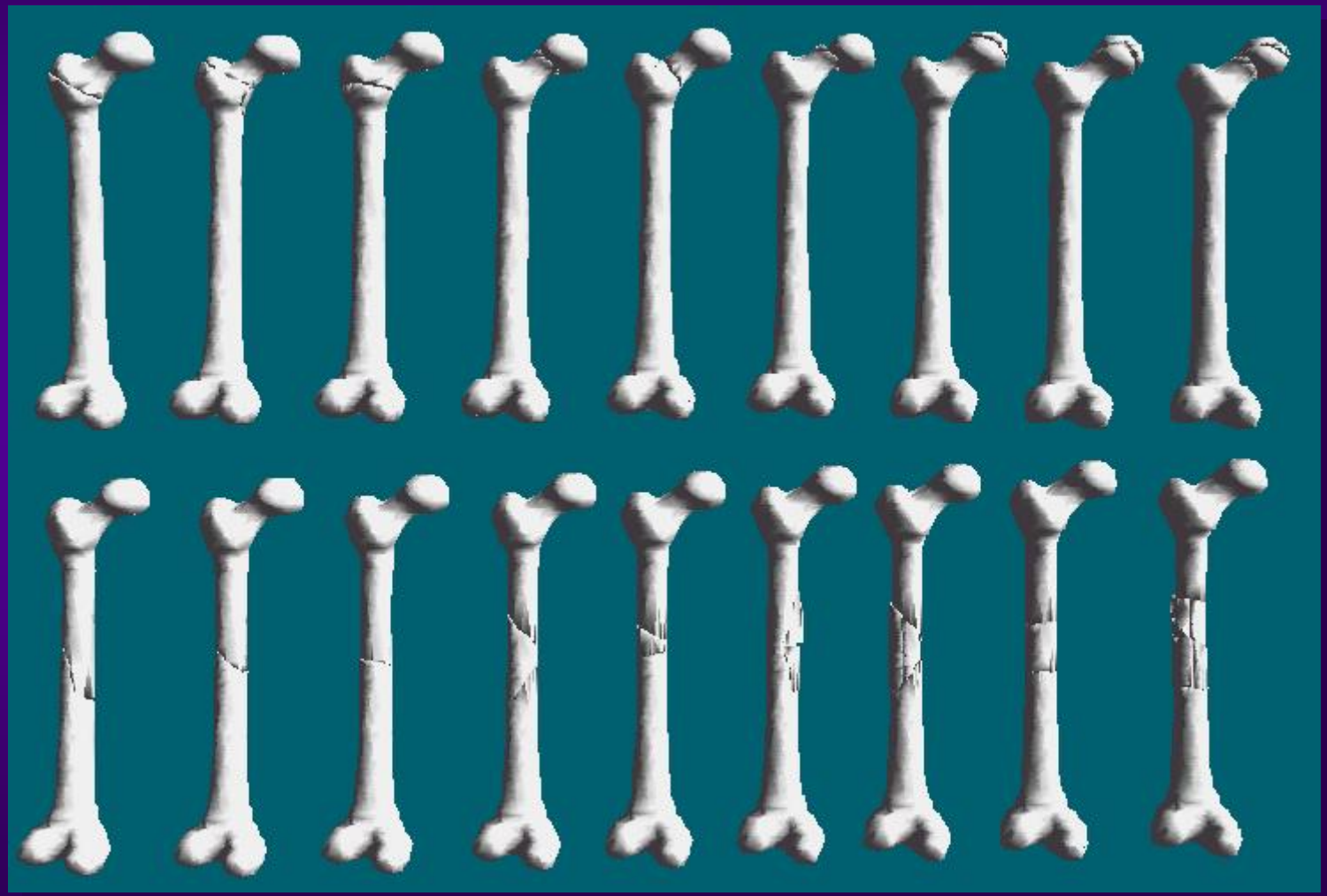
Fractured Bones

- Fractures exist in predictable shapes and can simply be modelled
- Special cases can be reconstructed from CT data

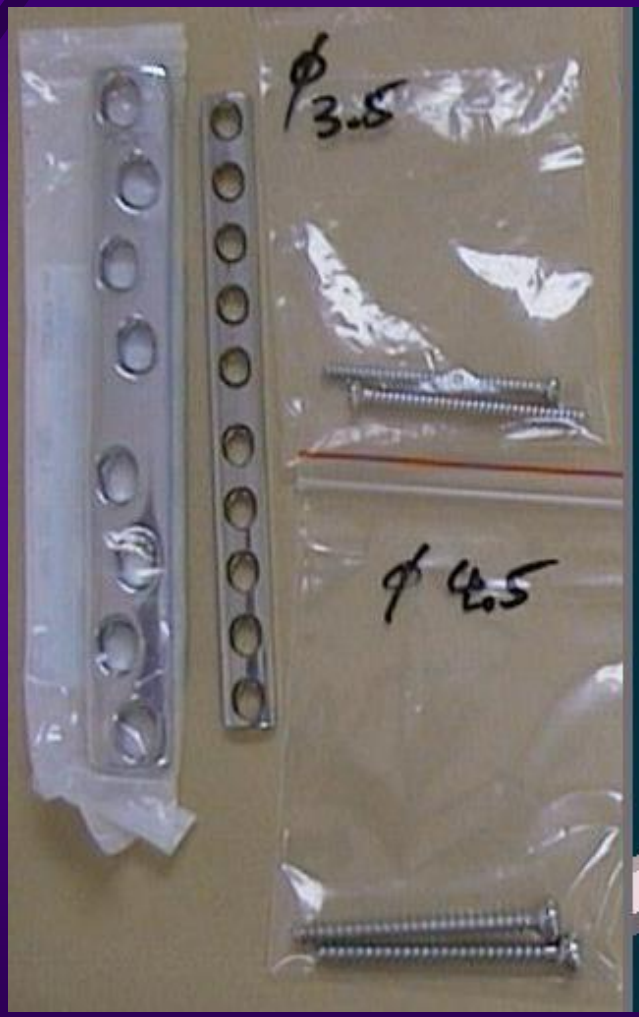
Standard Fractures. Example

- Femur
  - Proximal femur - 9 types
  - Femoral shaft - 9 types
  - Distal femur - 9 types
- Pelvis
  - Stable fractures - 3 types
  - Rotationally unstable fractures - 3 types
  - Totally unstable fractures - 3 types

Femoral Standard Fractures



Real and Virtual Implants



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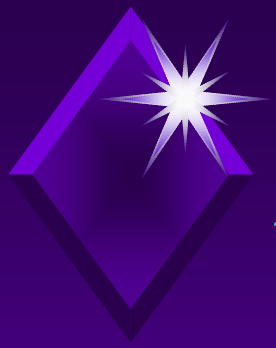


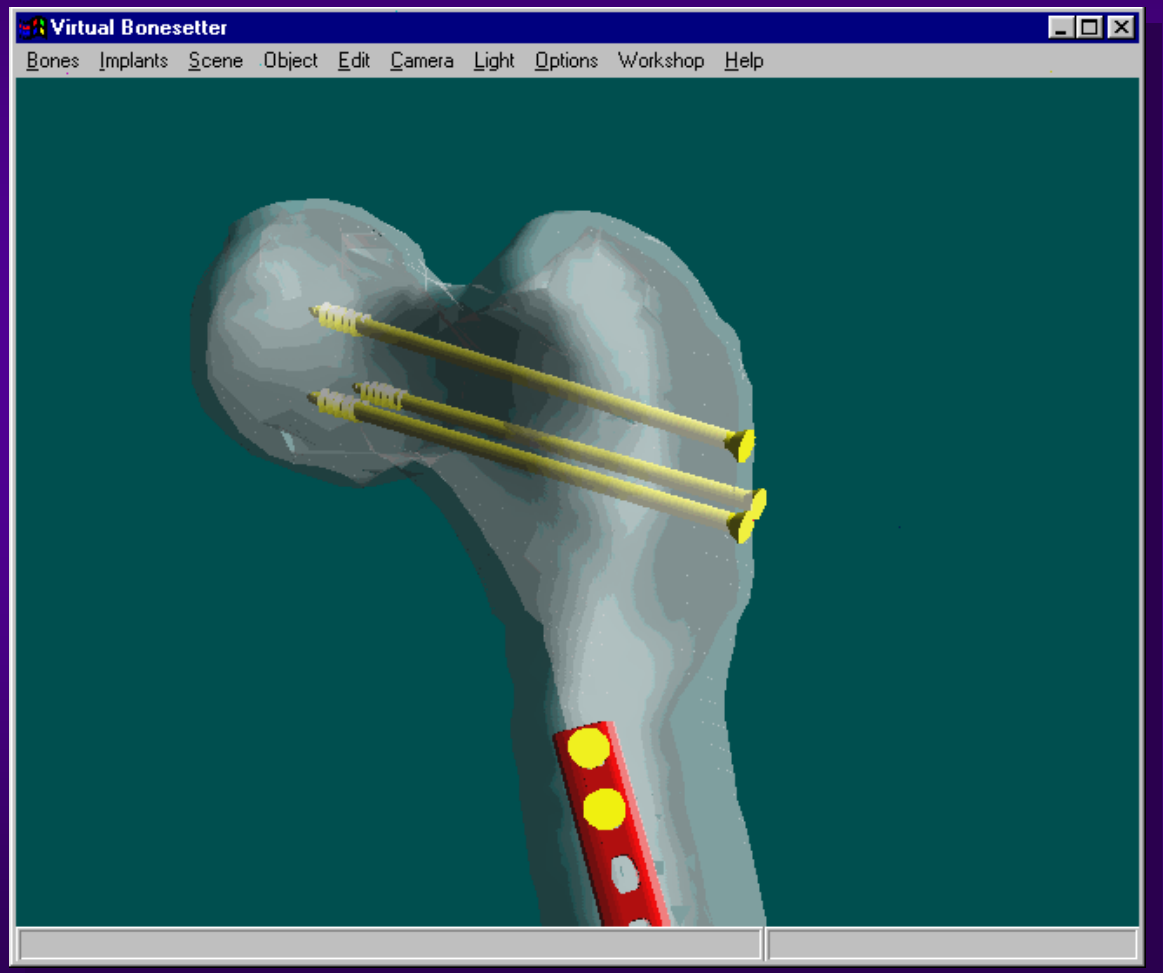
Basic Procedures Groups

- Application of the instruments and insertion of the implants in place
- Viewing the objects through “the image intensifier”
- Rotating and zooming the scene and objects in the scene
- Walk through the bone canal
- Reverse process
- Setting the multiple lights
  (point light sources and spot-lights)
- Setting the backdrop

Example of Virtual Surgical Procedures

- Locate the bone in front of the user
- Insert threaded guide wire
- Insert pin
- Remove threaded guide wire
- Remove pin
- Insert multiple guide wires
- Measure for screw length
- Insert screw
- Seat plate
- Insert nail

Femur Neck Fixation with Cancellous Screws



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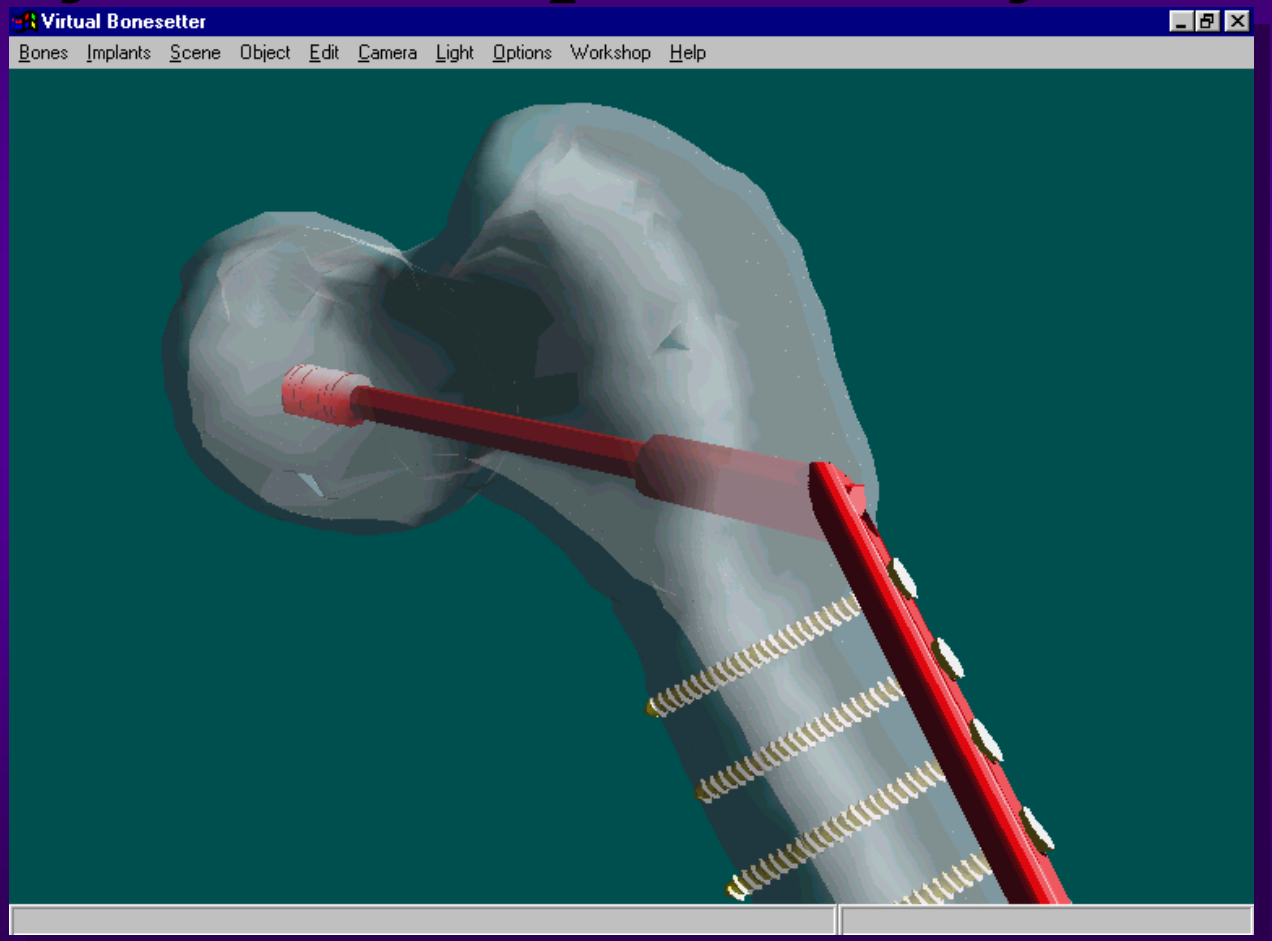
Femur Neck Fixation with the Dynamic Hip Screw System



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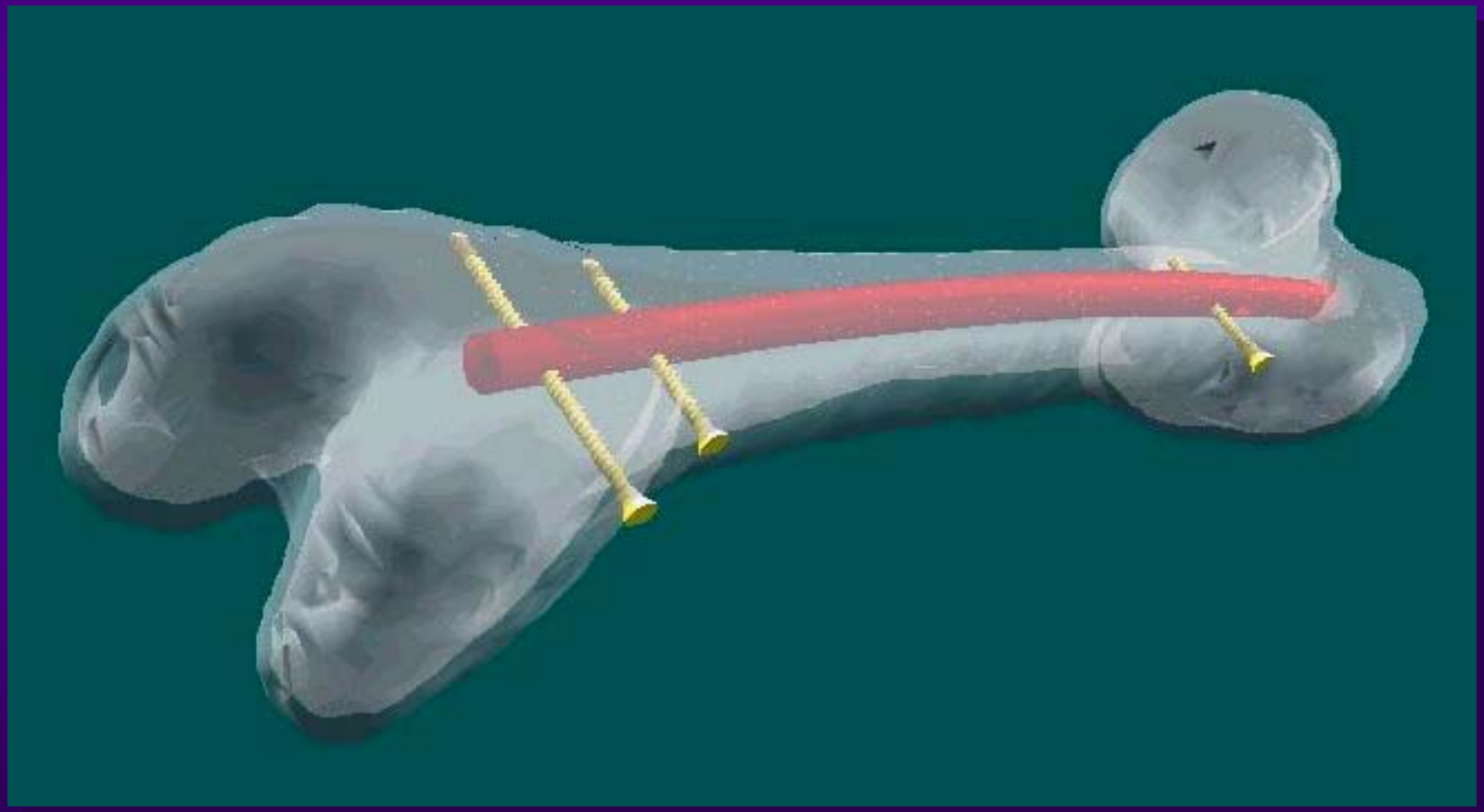
Femur Fixation with an Intra-medullary Nail



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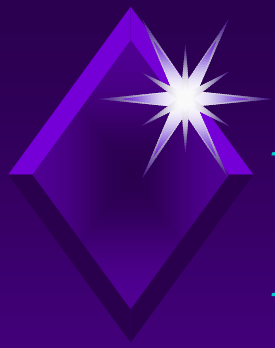


Hierarchical Geometric Database

- Fractured Bone or Implant
  - Unique ID
  - Shape - polygonal mesh
  - Graphics attributes
  - Extra geometric information used for pseudo-physical collision detection and/or insertion/seating
  - Parent reference

Example of Hierarchy

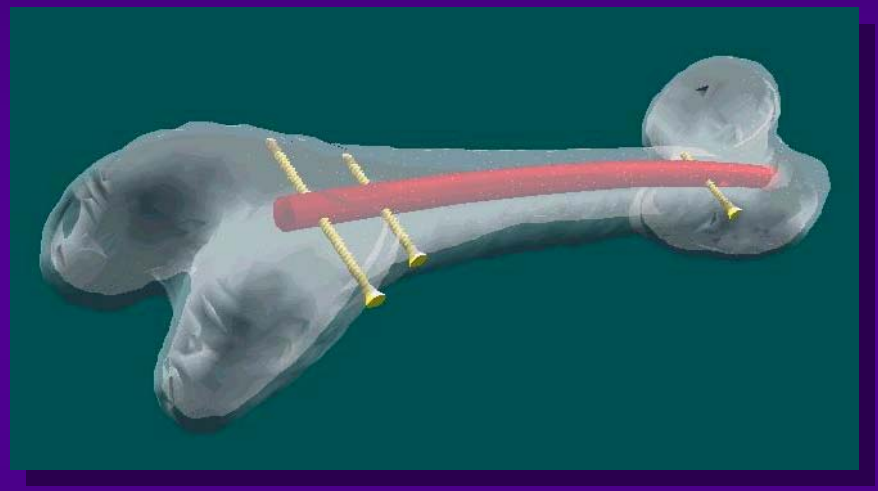
Fractured Femur

Nail

Screw

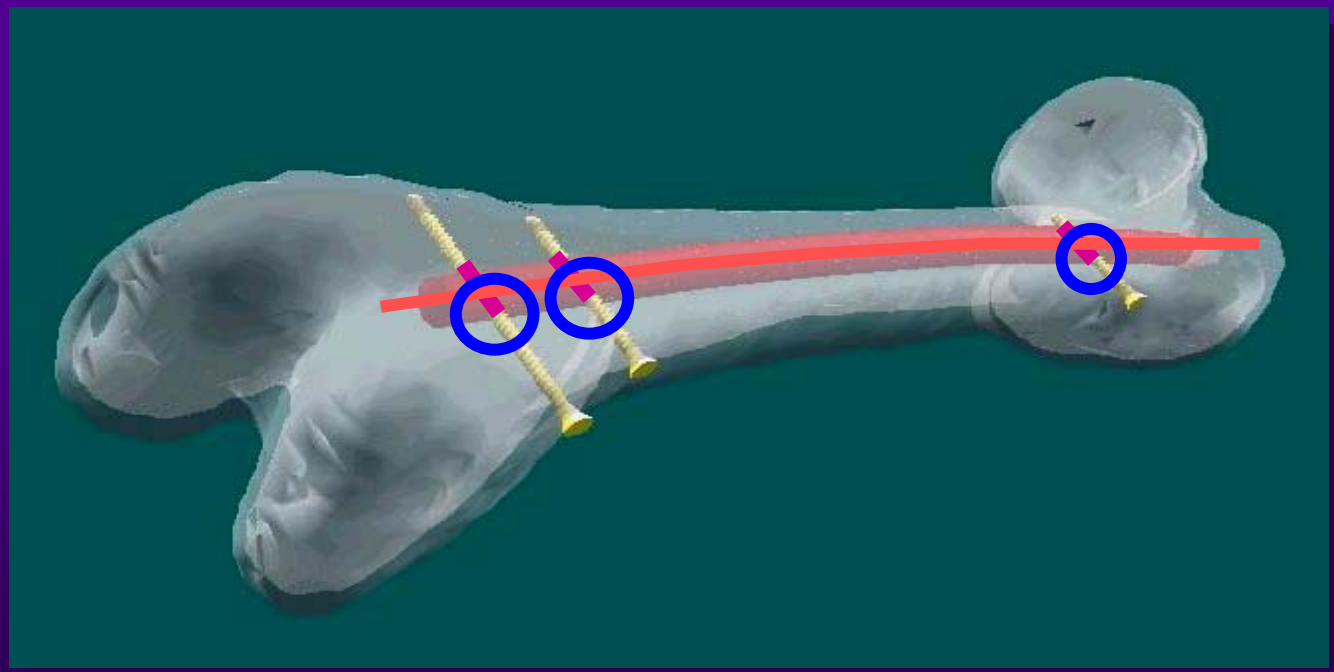
Screw

Screw



Example of Collision Detection

- Geometric attractive field + axis or centre point(s)



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Further Development

- To extend the library of tools and implants
- To develop a geometric library of fractured bones
- To add other specific surgical procedures
- To incorporate video of actual surgery procedures

Conclusion

- VB provides the capability to combine 3-D visual imagery of bones with interactivity in support of a realistic surgical simulation.
- The system could offer many attractive possibilities: lower risk training for students, fewer risks for patients, better scenario-based practice, and minimized cost of training.