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
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
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

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
Femur Neck Fixation with the Dynamic Hip Screw System
Femur Fixation with an Intra-medullary Nail
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)
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.