Graphical User Interface

Figure 6 – GUI showing performance feedback

LabVIEW was used for the GUI and is based on graphical (G) programming.

Future Developments

- Extend range of bone screws and surgical practices
- Improve accuracy of torque data
- Include the effects of force
- Include the whole insertion process
- Extend GUI to show 3D image of screw insertion
- Include effects of elastic bone response

Conclusion

An orthopaedic simulator has been designed that simulates the torque experienced during medical hand screw insertion. The simulator involves a mechanical feedback system with data acquisition cards, microprocessor and GUI. It utilises known torque/rotation data as part of the feedback control system. Patient variability has been incorporated as part of the GUI that provides performance feedback.

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- Alex Wiseman
- Geoff Cottrell

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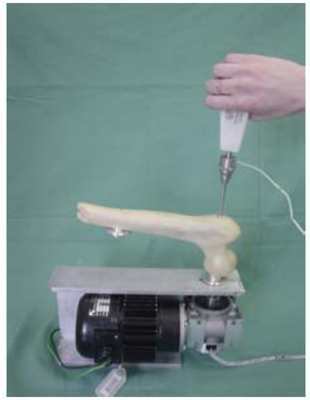
FLINDERS UNIVERSITY
ADELAIDE • AUSTRALIA

School of Informatics and Engineering

ORTHOPAEDIC SURGICAL SIMULATOR



Honours Project Exposition

2003

Chantelle Saegenschnitter

Tania Walker

Project Aims

The aim of this project was to design a feedback controlled orthopaedic surgical simulator, with a focus on hand tightening bone screws over the last rotations without over-tightening.

Background

Bone is composed of cortical bone (hard outer layer) and cancellous bone (inner spongy structure). Orthopaedic screws are used to internally fix bone fractures by compressing the bone. Cortical and cancellous screws are the most common.

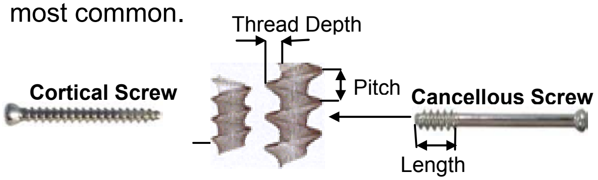


Figure 1 – Screw types and geometry

Screw geometry is a determining factor for screw holding power, which is proportional to the maximum torque required to strip the thread from over-tightening. This can also result in additional bone fractures, and the need for further surgery. Currently surgeons practice on synthetic bone and cadavers, or gain experience by feel on humans.

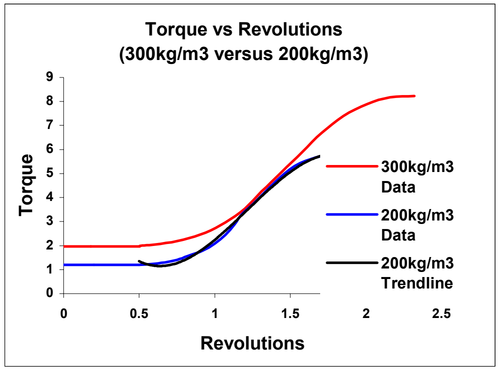


Figure 2 – Torque vs revolution data and trendline

The maximum stripping torque varies between 1-8N.m^2 and is predominantly dependent on:

- type of screw
- bone density/type.

Torque is directly related to the rotation of the screw, where the torque increases rapidly when the screw head contacts the bone as seen in figure 2. A trendline was plotted to form the basis of an algorithm for scaling the curve.

System Overview

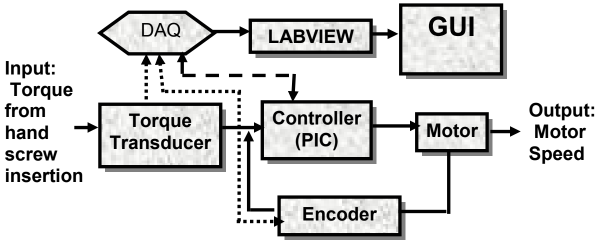


Figure 3 – Control system feedback loop

Design specifications:

- Variable torque/rotational feedback
- Indication of stripped bone
- Patient and screw variability
- Maximum torque 10N.m
- Velocity of motor approx. 1rev/s with minimum of 100CPR
- Graphical user interface for performance feedback

Hardware Design

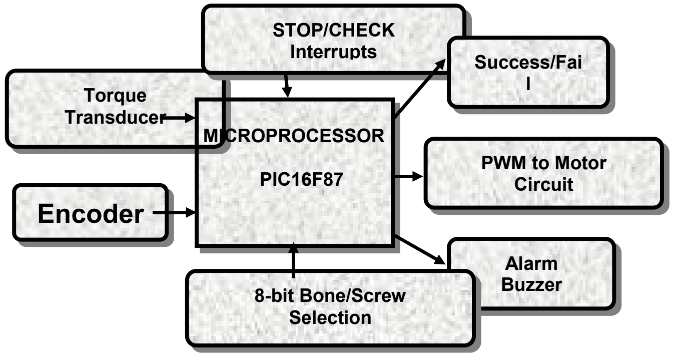


Figure 5 – Hardware design with inputs and outputs

Data Acquisition

The Advantech PCL-818HG data card was used for acquisition of the torque and rotational information. Two daughter boards were also used as relays for digital input and output between LabVIEW and the microprocessor.

Mechanical Design

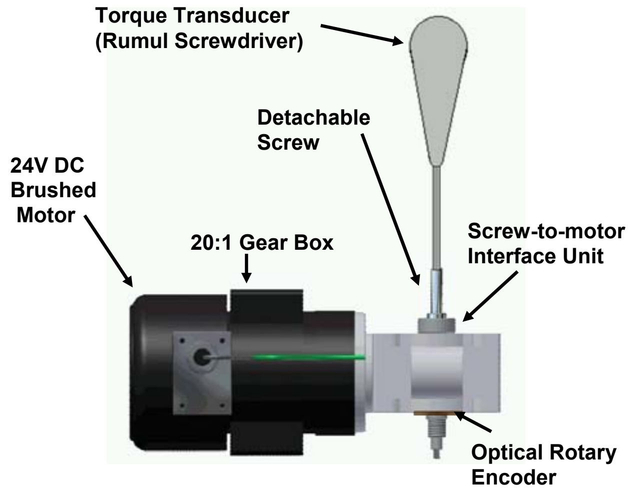


Figure 4 – Mechanical design for feedback control

Pulse width modulation is used to change the speed (torque) of the DC motor by varying the input voltage. A Darlington circuit is used to provide sufficient current gain required by the motor. The motor is geared to increase the torque and decrease the speed.

The Rumul screwdriver is similar in dimensions to an orthopaedic screwdriver, and utilises a full bridge of strain gauges.

An optical encoder (500 counts per revolution) was used to provide rotational information to the PIC and data card.