# MECH 459 - Three-Dimensional Haptic Emulation of Hard Surfaces with Applications to Orthopaedic Surgery

The device built for the 2008-2009 MECH 459 course in connection with Praxim is the predecessor to the current prototype development. The device aims to use reduce the amount of bone removed during orthopaedic surgery of the knee.

## How does Praxim 3D Haptic Hard Surface emulation work?

The device utilizes the Dynamic Physical Constraint mechanism developed by Nikolai Hungr in three-dimensions to implement a desired haptic hard surface without constraining motion away from this surface.

The hard surface is implemented passively by a stopper positioned between two linkages. The position of the stopper is controlled constantly by a systems consisting of a motor, a controllers and two encoders and positioned according to the current location of the input at the end of the second linkage. The user controls the input by holding onto a tool – drill – connected at the end of the second linkage and will not sense any active input from the device away from the surface.

## Functions

The following section will discuss the performance of the Praxim 3D Haptic Hard Surface emulator with respect to the functions identified for the current device.

### User Interactions

* Installation and mounting
  + This prototype does not have any mechanism to connect to a patient. In its current form the device could be placed next to the operating table and the patient’s knee would require additional contraining.
* Model Input
  + Surfaces generated by the device are coded into the controller and based on functions entered by the user. The user can select from three surfaces at the controls interface using a combination of four buttons.
* Tool Connection
  + Tools are connected at the end of the second linkage by a hole. There are no means to secure tools in this position or to implement different sized tools.
* Device motion
  + The device allows for complete motion away from the hard surface with three degrees of freedom. The device however cannot support its own weight and when user releases control the device will move due to gravity.
* On/Off Functionality
  + The device must be connected and disconnected from the power source in order to operate.
* Sterilization
  + There is no means to sterilize the device in its current form . A sterilized sheet could be used to cover the majority of the device but the motor will likely be exposed and has no over.
* Maintenance
  + N/A
* Positioning calibration
  + Any orientation or calibration of the position of the surface must be done at these functions and therefore cannot be easily be completed with respect to a patient’s knee.
* Positioning awareness
  + The position of the user input is constantly updated and the dynamic physical constraint is positioned accordingly, however the user has no means to determine whether these updates are taking place or how accurate they are.

### Autonomous

* Provides tool/position constraint
  + A hard surface is generated based on the series of functions mapping out the haptic surface. This surface is fixed and does not allow for any leeway and if approached at with some force will cause the mechanism to rebound in the opposite direction.
* Monitoring/awareness of too position
  + The tool position is constantly updated and the dynamic physical constraint is position accordingly.
* Three-dimensional movement
  + The device provides the user with three degrees of freedom, all translational – no rotational motion. There is only one active joint which allows for very smooth positioning and control away from haptic surface – motion is completely passive away from the haptic surface.
* Convert input into traceable surface
  + Currently there is no means to implement patient specific surfaces.

### Modes of operation

* On
  + The device is active and the physical constrain position is updated constantly based on desired haptic surface input. A red light indicates which shape has been selected.
* Off
  + The system is completely inactive.
* Idle
  + Before the desired haptic surface has been selected the device will remain completely passive where lights on the controller display the available shape options.

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