

CSCI 599 Physically Based Modeling for Interactive Simulation and Games

Topic: Haptics

Mathematica

It is a powerful tool. It can be used to check if the code works correct.

Simple usage by example:

1. compute logarithm : `log[7] // n`
2. expand polynomial formula : `(a + b)^2`
`Expand [%]`
3. draw graph : `plot [%, {x, -1, 1}]`
4. input matrix : `M = {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}`
5. show M in matrix form : `M // Matrix Form`
6. compute determinant of matrix : `Det[M]`
7. SVD : `SingularValueDecomposition[M] // N`
8. Solve equations : `Solve[{x * x + y * x + y * z + 3 * z = 1, x + y - z = 2, x * y * z = 5}, {x, y, z}]`
9. show animation : `Animate[Plot[sin[x]*cos[y], x, 0, 4 * pi], {y, 0, 4 * pi}]`
10. user-defined function : `trace[{a_, _}, {_, b_, _}, {_, _, c_}] := a+b+c`

Haptics

1. Overview

Haptics is a tactile feedback technology that takes advantage of a user's sense of touch by applying forces, vibrations, and/or motions to the user. While computer graphics create the image on the screen, Haptics devices take user's input and generate the illusion of touching to user.

It can be used on robotics. User holds the robot arm and the arm keeps track of its position and motion and operates the 3D object on the screen to do the corresponding movements. And it will apply collision detection. Once the 3D object hit the other stuff, the device will create illusion of touching like pushing user's arm with a slight force.

The haptic device generates forces very quickly, usually thousands of times per second. It connects to the computer with speed of more than thousands bytes per second.

The haptic device has two parameters. One is the maximum force apply to the user. To avoid harm the user when fault occurs, the device will not generate a large force. The other is the duration it works. Long time vibration or force generation may damage the device, so the force it generate only remains for a shot time.

2. Devices and applications (images come from Google Images)

1) 1-DOF device – shake

This kind of device usually used on cell phones. It can only generate vibrations when touching the screen.



2) 3-6 DOF device

3-DOF device keeps track of position and 6-DOF device not only keeps track of position but also the direction.



sensable

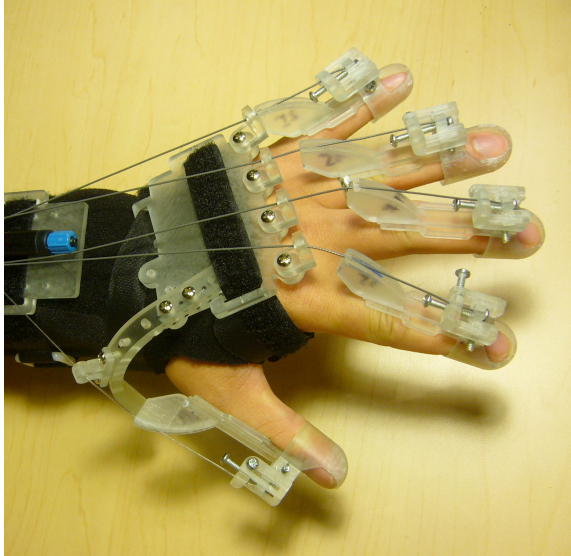


falcon

3) bimanual interfaces

It takes operations of both left and right hands.

4) grasping capabilities



5) training

One of important application is on medical training. Medical student often don't have enough resources to practice. So using these kind of devices they can practice more often. The current problem is some devices are not so precise as the their advertisement say.



medical training

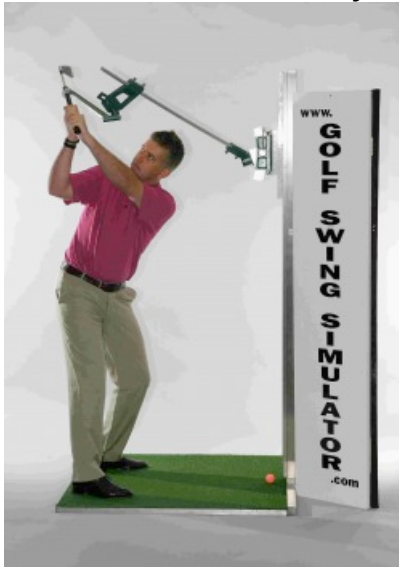
The other kind of application is on engineering training/design. Though the devices are quite expensive, applying these devices can still save lots of money.



engineering training

6) golf trainer

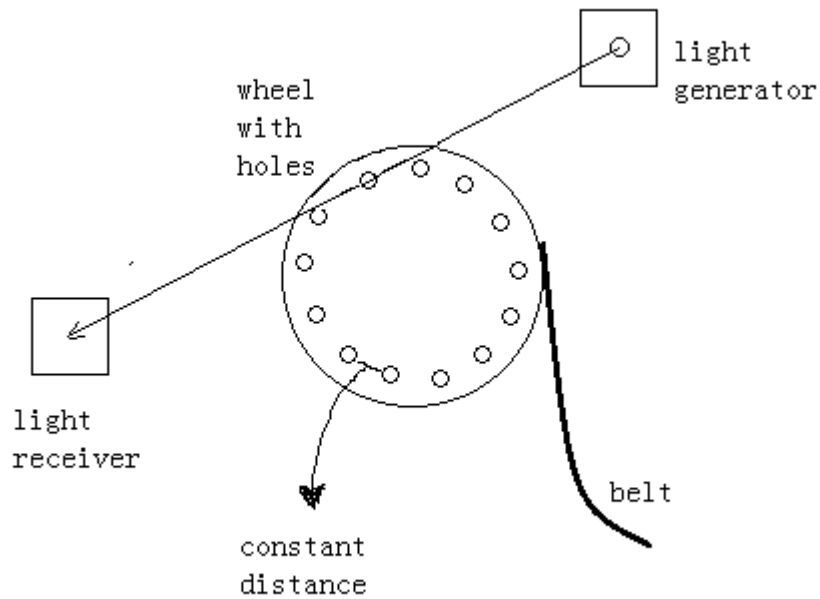
It takes golf player's motion and corrects his/her gesture. It is more like a rich's toy.



7) ultimate workstation

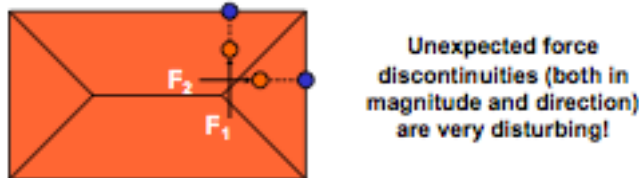
3. How it works

The haptic device can track position by the device shown below:

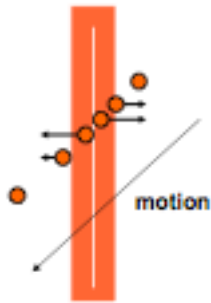


A light generator shoots a ray to the receiver. And a wheel is placed in the middle of generator and receiver. The wheel has bunch of tiny holes on its rim and each of holes is quite close to each other. A belt is tied on the wheel, and the other end is connected to the haptic device. When the belt moves, the wheel rotates and ray interrupted by the wheel. So the device can count how many interruptions and thus compute how much distance the belt moves.

The haptic device can detect collision to other objects on the screen. It uses penalty method to do the collision. It checks if cursor penetrates an object. If so find the closest point on the object surface and then compute penalty-based force using formula $F=kx$. But the problem may happen when crossing boundaries of internal Voronoi cells as shown below:

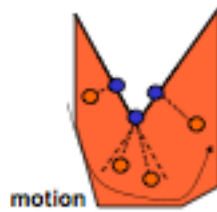
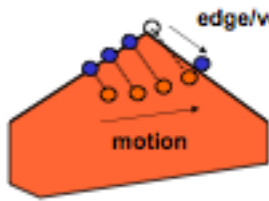


And when penetrates into thin object as shown below:



After the mid line is crossed, the force helps popping through.

So another method is introduced. It is called "God-Object" which main idea is that the cursor will not go into an object, it always touch the outer object surface when hitting that object.



Concavity: 2/3
constraint
planes in 3D