Biomechanics
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Lecture - 83
Demonstration of the Hand Kinematics Measurement System

Hi welcome to this course on biomechanics. I am Prajwal Shenoy and I am the teaching assistant for this course. In the past few videos, we saw how to parameterize rotations when using devices like electromagnetic tracking sensors and IMU. We looked at rotation matrices Euler angles and quarter means we saw some of the properties of these methods the advantages and disadvantages of these methods.

And also, some of the mathematical operations that can be used while using this parameterization methods. We then used these methods to compute the kinematics of a single finger and animated it while using the kinematic measurements using the IMUs and then we extended this to the measurement of full hand kinematics using 16 sensors. In this video, we will look at a practical demonstration of how to measure the full hand kinematics using the 16 sensor system that has been developed.

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This is the device which consists of 16 sensors and these sensors will be attached to the appropriate positions on the phalanges of the fingers and on the wrist. So, all these sensors are connected to the main receiving board consisting of 5 microcontrollers. This device is capable of generating data at a rate of 100 Hertz. You can see each, sensors are connected to each other as well as it is connected to the main board with the help of flexible cables also called as FFC cables.

These cables are very rugged and they will not snap during the operation or during the data collection process. This is the printed circuit board which consists of the main chip bno055 and all other components that are required for the operation of this device. This is made to be as slick as possible for a size of 1 centimetre by 1.3 centimetre. On the back there is an option to attach the FFC cable with the help of an FFC connector.

So, this can be connected to the FFC cable and snap fit the cable in place. So, this forms a very rugged contact and will not snap out during the operation.

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So, as mentioned earlier this device can output data at a rate of 100 Hertz. So, if you collect data for one second the data will look like it will have 100 rows because it is giving 100 samples in one second and it will have 64 columns. Why will it have 64 columns? This is because we are using 16 sensors and each sensor is programmed to produce quatrain output and we have seen previously that quaternion uses four values to describe orientation.

And hence since there are 16 sensors, we will have 16 into 4 64 columns. So, this will be the magnitude of data that will be coming out for one second. I now request my lab mate Anuragh Gupta to give a brief description of working of this device. Thank you Prajwal as already mentioned by Vardhan Sir in one of the previous videos the hand kinematic measurement system consists of five microcontrollers connected in the master slave configuration.

This master slave arrangement was designed in order to output orientation data from all the 16 IMU sensors at a rate of 100 Hertz.

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This is a zoomed in version of the HKMS device it consists of the master microcontroller here and the four sleeves each slave is connected to three IMU sensors connected in series. And these three IMU sensors are connected to individual finger phalanges of a single finger. For the master microcontroller four IMU sensors are connected in series one to be placed on the wrist and free to be placed on the individual finger phalanges of the middle finger.

The working of the master sleeve configuration is as follows or the master microcontroller sends an interrupt every 10 milliseconds to the four slaves in the form of a rising edge. The slaves upon receiving the interrupts start to collect data from their respective IMU sensors. In the meantime, after sending the interrupt the master microcontroller starts to collect data from the four IMU sensors that are connected to it.

And then waits for the data from the slaves to arrive. Once the data from all the slaves have arrived the master then sends the data from all the 16 sensors via USB to a computer. This entire process happens within 10 milliseconds before this the master sends its next interrupt. Hence achieving a data output rate of 100 Hertz.

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We will now attach the sensors to the hand and demonstrate the working of this device.

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This is the animation of hand movements that is in real time and modelled in MATLAB Simulink. In order to do this coordinate data from all sensors are read through the serial communication in MATLAB Simulink. The relative cotton unit each joint is computed using the conjugate quantum operation which is later converted to Euler angles and then animated. But please note this is not the only way to do this animation it is not always necessary to convert the quaternions into Euler angles.

There are some softwires and tools which take in coordinates directly and animate in real time. We will also demonstrate that in a few seconds. This is a VR based application which is developed using the unity game engine software. This application accepts kinematic data from two HTML devices and uses it to animate a pair of virtual hands in VR space the animation of the virtual hands is done using raw quaternion data.

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With this we come to the end of this video. In this video we saw a live demonstration of the full hand kinematic measurement system using 16 IMUs. We saw the construction we saw the working we also saw the method of attachment and an animation using MATLAB Simulink and unity software. Thank you very much for your attention.