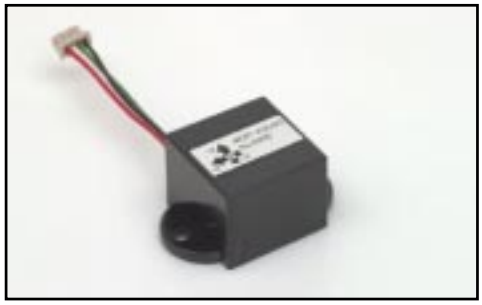
3D Motion Sensor
Outline
Features
Structure
Applications
Glossary

Outline　The 21st century is the era



3D Motion Sensor

Developers Kit

Until a few years ago, only expensive workstations could display 3D computer graphics in real time. Today, however, it is taken for granted that a home PC or game console will be able to use 3D graphics. The majority of video games today make use of 3D computer graphics, and many creative CG designers are now using PCs to create 3D computer graphic animation.

But the increasing use of the PC in this arena has brought a new problem to light: the interface used to manipulate the 3D graphics. A good example of this is the PC game called Quake III. This is a world-famous combat game played out in a three-dimensional space. The controls used for this game are anything but intuitive: the arrow keys are used to walk forward, backward, right and left, while the mouse is used to aim the gun. This is an extremely confusing setup, but existing computer interfaces have not been capable of anything more sophisticated.

Up until now, conventional input devices - including the mouse, keyboard and game pad - were only designed with a two-dimensional screen in mind. Truly navigating a three-dimensional space will require a new type of input device, one more suited to this new format. Two examples are the 3D mouse and the tracker of the head-mounted display (HMD). These new types of interface require compact, high-performance sensors to detect motion in three dimensions, including an object's position, orientation, and movement.
Furthermore, this type of sensor will be able to dramatically improve the accuracy of mobile phone and PDA positioning services, a field with huge growth potential. The applications for 3D motion data will no doubt expand greatly in the IT field of the 21st century.

Features　Trumps High-Frequency Noise

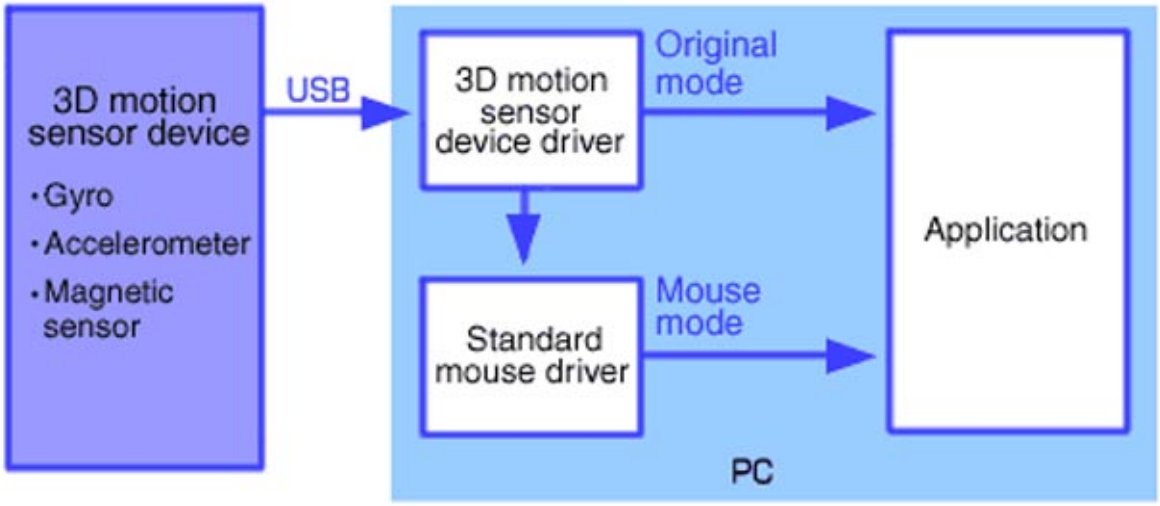
NEC TOKIN's 3D motion sensor is a system combining an accelerometer and magnetic sensor with a NEC TOKIN Ceramic Gyro™, which has a 10-year proven track record. This combination supplements the deficiencies of each sensor, allowing extremely accurate 3D motion detection with a simpler construction and lower price than ever before.

And because the 3D-motion sensor has a USB interface, it can be easily connected to just about any PC. It carries Windows 98, Me, Windows 2000,and XP-compatible drivers, and also offers an application to convert the 3D motion sensor signals to mouse control signals.

Items		Specifications
Output Form		Z-Y-X Euler's Angle
Dynamic Range	α (Yaw angle, Z-axis)	± 180 deg
	β (Pitch angle, Y-axis)	± 90 deg
	γ (Roll angle, X-axis)	± 180 deg
Resolution	α (Yaw angle, Z-axis)	1 deg
	β (Pitch angle, Y-axis)	1 deg
	γ (Roll angle, X-axis)	1 deg
Maximun Error	α (Yaw angle, Z-axis)	± 10 deg
	β (Pitch angle, Y-axis)	± 10 deg
	γ (Roll angle, X-axis)	± 10 deg
Data update speed		125 Hz
Interface	USB	Comforms with USB spec.1.1
Power supply voltage		DC5V (to be supplied via USB interface)
Current consumption		100mA or less
External Dimensions	Width × Depth × Height	20 × 20 × 15mm (Typ)
Weight		6g (Typ)
Operating Temperature		0 ～ 40 degrees centigrade
Applicable machine		IBM PC/AT 100% compatible machine/\ with USB interface
Applicable OS		Microsoft Windows 98SE, Me, 2000, XP

Note: Windows is a trademark of U.S. Microsoft Corporation registered in the U.S.A. and other countries.

Functional Block Diagram



Original mode

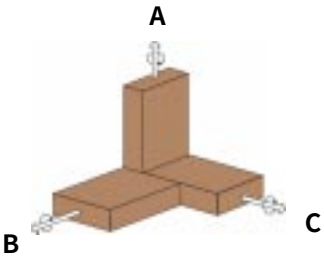
In this mode, the angle is computed using the data from the 3D sensor and the result is sent to the application software.

Mouse mode

In this mode, the angle is computed using the data from the 3D sensor and the mouse's cursor motion is emulated, then the emulation data is sent to the application software.

" 3D Motion Sensor "A Combination of 3 Ceramic Gyro™

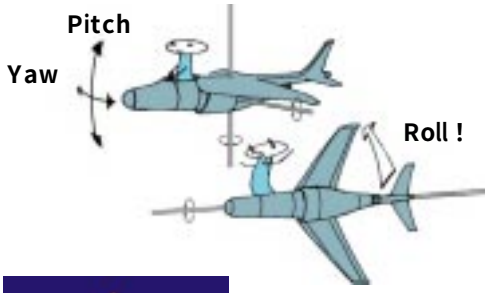
One Ceramic Gyro can measure the rotations of one axis. Two gyros that combined at right angles can check rotations for two axes (vertical and horizontal) and measure 2D movement. This technology is used for cameras and other devices. Further, combining three ceramic gyros enables measuring of 3D rotations by measuring the rotations of three axes. This "3D Motion Sensor" is a sensor that can check the position at that time no matter what direction (back or front, right or left, roll or pitch) the object is in.

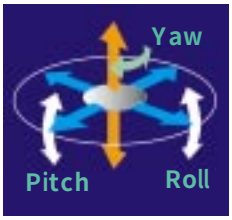


As shown in the figure above, when three Ceramic Gyro™ are used along with three right angled axes (a, b, and c) , this allows 3 dimensional rotations to be measured.

3 Dimensional Rotations

When these three rotations are combined, the rotation becomes 3 dimensional. These three rotations are called " pitch ", " yaw ", and " roll ". The figure shown below illustrates an example of airplane rotations.

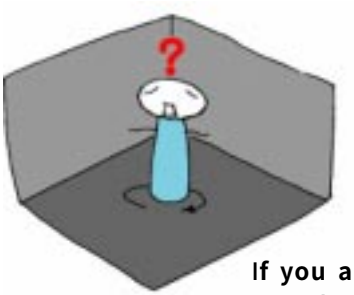




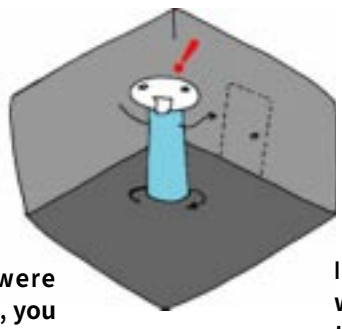
When these three rotations are combined, the rotation becomes 3 dimensional.

Basis - Factors required to learn the position -

However, a 3 dimensional position cannot be detected when using only Ceramic Gyro. Ceramic Gyro can detect " the amount of rotation "; however, they cannot detect the position and direction" from what state "; i.e., the position and direction used as reference cannot be detected. For example, you are in a dark room, you are spun around then you are told that you were spun two and half rotations. Do you think you could find the exit? The answer is probably no. However, if the room light was on and you could remember where the exit was before being spun around, you could probably find the exit after turning the light off and spinning based on how many rotations you were spun. In this example, the" exit "is the reference point for the position and direction. 3D Motion Sensor needs the same information, which is called a "basis."



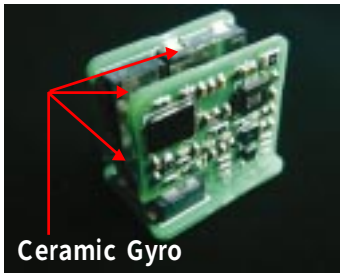
If you are told that you were spun two and half rotations, you would not be able to find the exit because you did not know where the exit was beforehand.

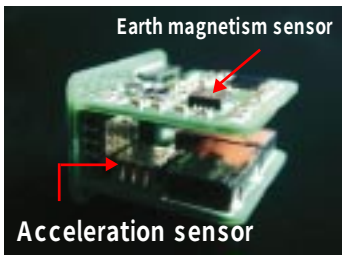


I saw the exit on my right, I was spun two and half rotations, so...
The exit is... over there!

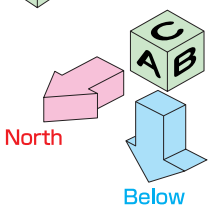
Earth Magnetism and Gravity as Basis

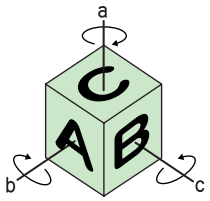
Then, two factors that are most common on the Earth are selected as the basis. They are the Earth 's magnetism and gravity. People have used the Earth 's magnetism to know where" North "is from ages past. Moreover, if a sensor can detect the direction of gravity, you could find the direction directly below. The " Magnetic Sensor " detecting the direction of the Earth 's magnetism is like a compass, and the " Acceleration Sensor " detecting the direction from where gravity is being applied, are combined with three Ceramic Gyro™ in order to detect a 3 dimensional position. This fulfills the "3D Motion Sensor."





Imagine a box (shown on the left) where 3D Motion Sensors are installed.





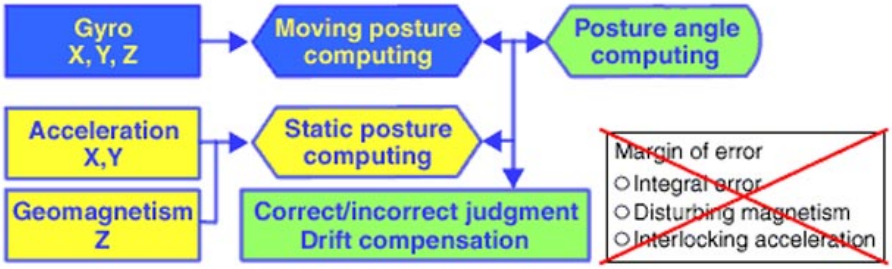
❶ Based on the information detected by the Earth magnetism sensor and the acceleration sensor, you could know the position where A faces to the North and the bottom faces directly below.

❷ 3 Ceramic Gyro™ can detect that there are a 1/2 rotation around Axis a, a 1/4 rotation around Axis b, and a 1/4 rotation around Axis c based on the state of item 1 above.

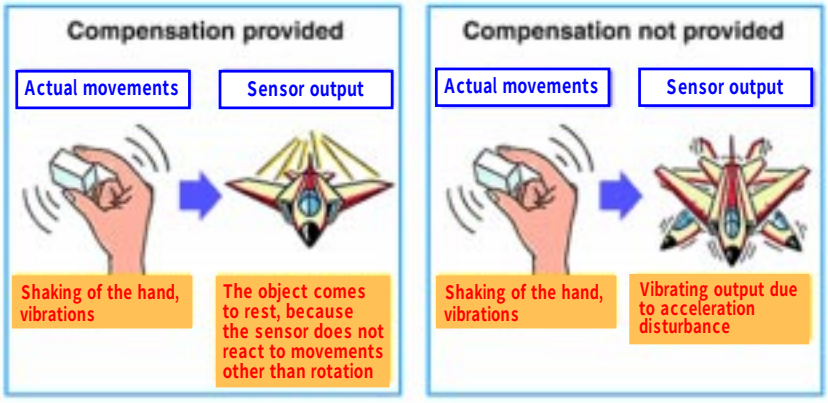
❸ According to the information obtained in items 1 and 2 above, you can know the current position as shown in the previous figure.

The Ceramic Gyro are arrayed to measure movement in each of the three directions - up-down, left-right, and front-back - and each of these gyros is then paired with one of the other sensors: magnetic in the up-down direction, and accelerometer in the left-right and front-back directions. In combination, these sensors can accurately measure motion in each of the three dimensions. During fast movements, the values output by the accelerometer and the magnetic sensors are supplemented by the gyros, while during slow movements, the values output by the gyros are supplemented by the accelerometer and the magnetic sensors.

Increasing Precision through Mutual Compensation



Effect of Mutual Compensation



3D motion sensors have an extremely wide range of applications, because they can accurately indicate the oriental position of items they are attached to.

The tracker of the HMDs

Using the 3D motion sensor in head-mounted displays (HMDs) used for virtual reality and remote-controlled robots enables the corresponding scene to be displayed whenever one's head is turned.

Application to HMD Trackers

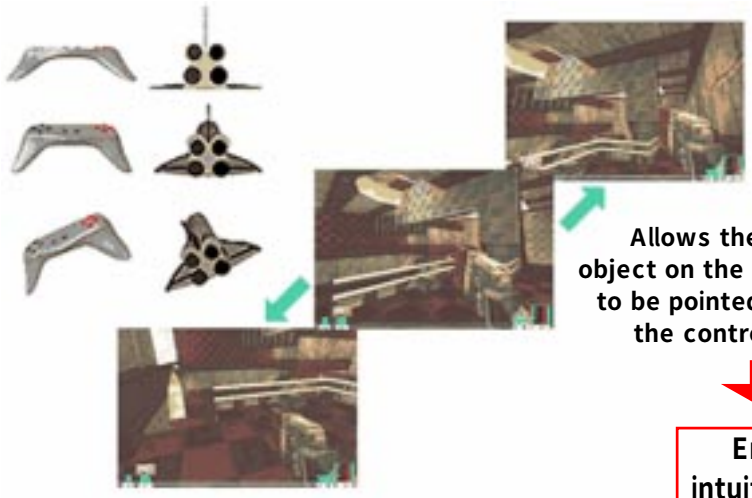
When looking diagonally upward and to the right

3D Video Games

Another possible application is in 3D PC and game console video games. Using one of these sensors for a shooting game will allow the gun on the screen to be pointed in the direction the controller is aimed, making this type of game much easier to operate.

One new type of game features characters which reproduce a human's movements very realistically. Called motion capture system, this system captures the movements of the human player and transfers them into the movements of the game character. Traditionally, this has required a special studio equipped with a huge system costing hundreds of thousands of dollars. But motion capture can be conducted using twelve 3D motion sensors, allowing for an extremely inexpensive system that is within the reach of smaller businesses and hobby users.

Application to Game Controllers



Allows the character or object on the screen or the gun to be pointed in the direction the controller is aimed.

Enables intuitive input

Positioning Services

As these sensors become more compact, it will be possible to embed them in cell phones and PDAs, improving the accuracy of positioning services.

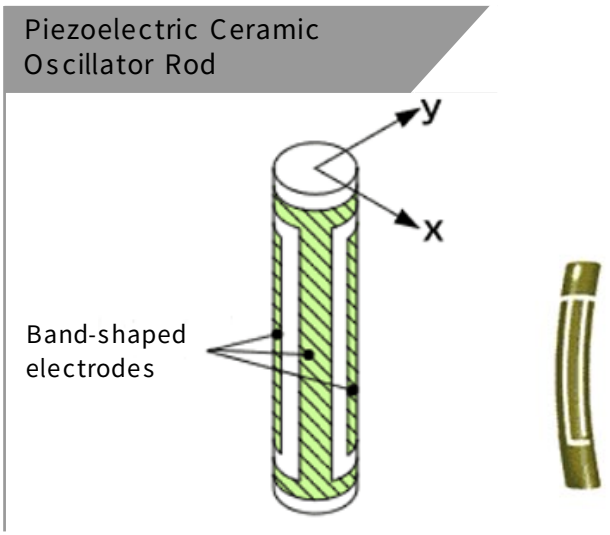
Positioning services indicate the location of a terminal's owner by using data from global positioning system (GPS) and mobile telephone base stations. There are a multitude of applications for this type of service. For instance, it can be used to locate people suffering from dementia if they become lost, display a map to nearby restaurants, or find out the current location of sales and service staff. But since GPS relies on radio waves from satellites, it cannot be used indoors and in areas with high buildings where these waves can't be received. And since the base stations of mobile phones cover wide areas, they can only serve as a very general indicator of position. Combining this data with 3D motion sensors, however, should allow for much more accurate services, capable of pinpointing one's location down to the exact room of the building where one is located.

The compact size, high precision, and excellent cost performance of the NEC TOKIN 3D motion sensor will give it use in a wide range of IT devices in the 21st century.

Ceramic Gyro™

Ceramic Gyro™ is a sensor that measures rotational (angular) velocity by oscillating a piezoelectric ceramic resonator with alternating voltage. The NEC TOKIN Ceramic Gyro uses an extremely simple construction: piezoelectric ceramic rods, to which electrodes are attached during the printing process. This gives the sensor consistent quality and a wide range of applications, including shake detectors for hand-held video cameras.

Piezoelectric ceramics change shape (stretch and shrink) when subjected to electric voltage. Alternately, they produce voltage when their shapes are altered. First, piezoelectric ceramic rods are placed horizontally at right angles to one another to form X and Y axes. Next, electrodes is attached to the X axis, and the two lines crossing the Y axis. Then when alternating electric voltage is applied to the electrodes on the X axis, the piezoelectric ceramic rods begin to oscillate back and forth along the X axis. If the electric potential of the two electrodes on the Y axis is measured at this time, there will be no change. This is because the piezoelectric oscillation is only occurring along the X axis, and no force has been applied to the Y axis. But if the ceramic rods are rotated on their axis, the oscillation of the X axis and vertical/Coriolis force are applied. When this occurs, potential appears in the electrodes on the Y axis in relation to Coriolis force. So it is possible to find out the rotation of the ceramic rods on their axis by looking at changes in electric potential.



Coriolis Force

Say you are now standing in the center of a huge disk, and are trying to throw a ball in a straight line. But this huge disk is actually rotating counterclockwise, yet you are not aware of this. So when you throw the ball, it will probably appear to curve to the right. In other words, you will sense a force that causes the ball to veer to the right. This apparent force is called Coriolis force. This is what causes hurricanes to spin clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

Head -mounted Display (HMD)

This goggle display is famous in the virtual reality field. Because images can be sent independently to the left and right eyes, HMDs can be used to display images that give the impression that one is in a three-dimensional space.

Global Positioning System (GPS)

This technology, developed by the US military, receives radio signals from a minimum of four satellites to let someone know their position, using the principle of triangulation. Car navigation systems use GPS to calculate the vehicle's position.