

## Ceva MotionEngine

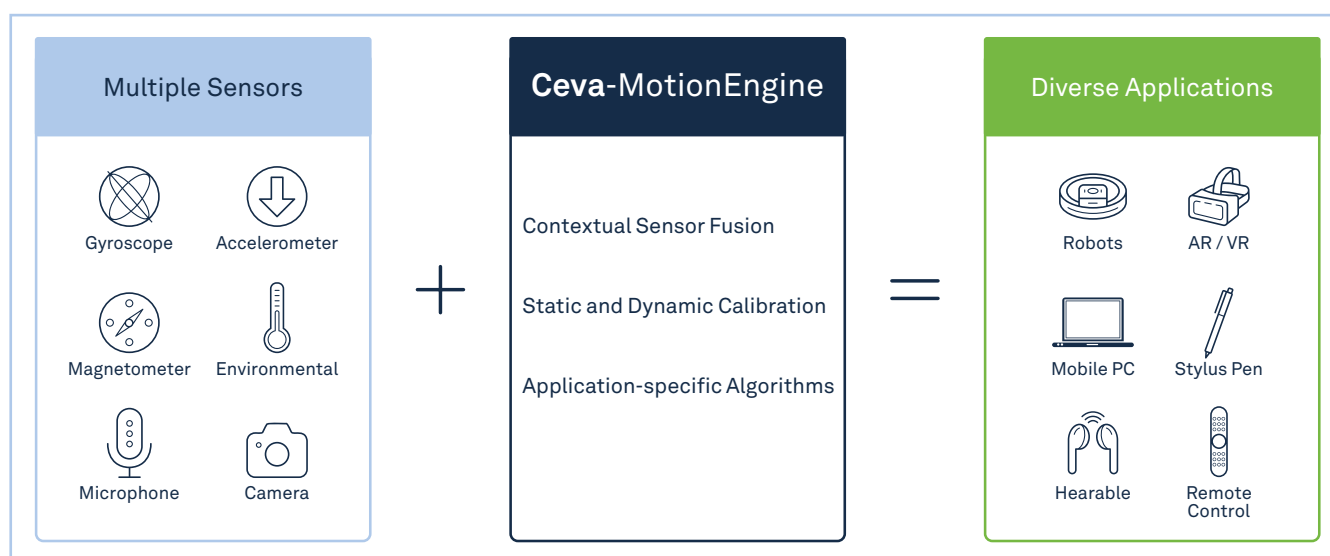
**MotionEngine** is a robust and feature-packed software system designed to solve the complex motion problems of today's consumer applications. Its broad reaching capability has aided with hearables, handheld remote controls, fitness devices, medical devices, mobile computing, XR, robotics, livestock tracking, and more. If an application needs to track motion, MotionEngine can help.



### Introduction

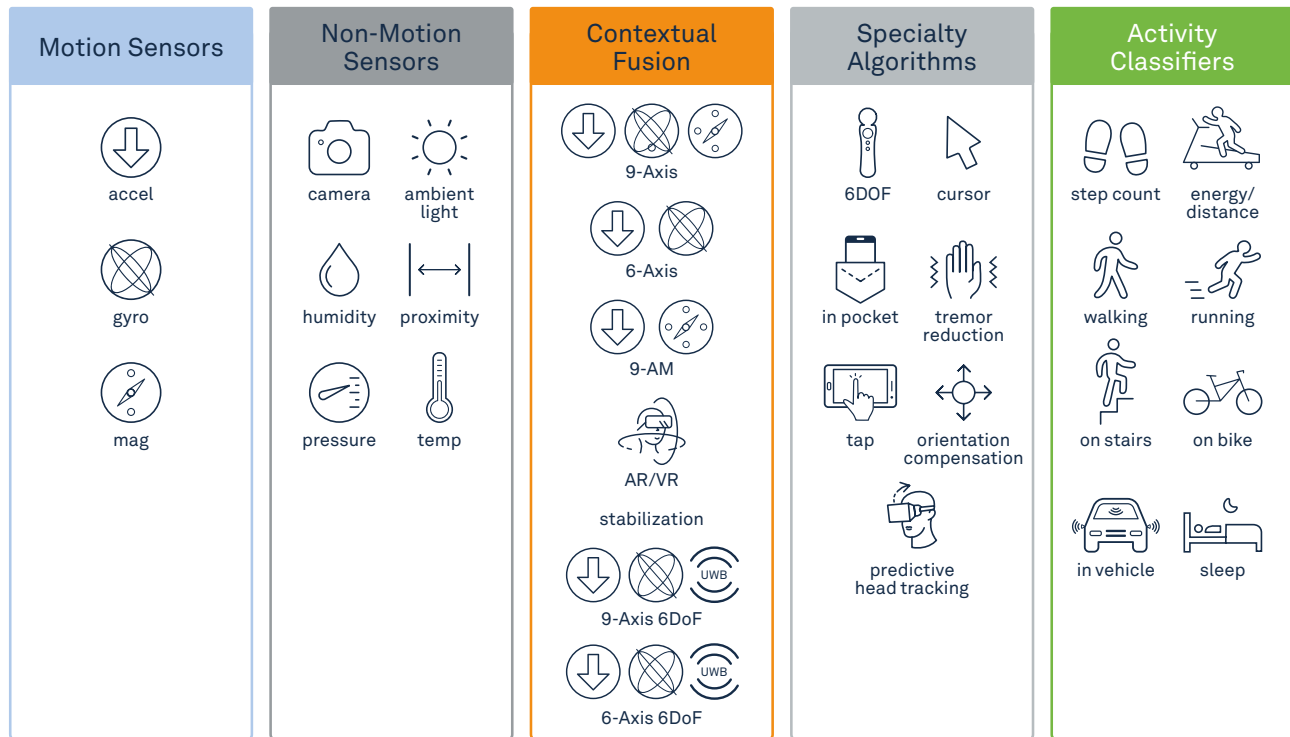
Ceva MotionEngine, which was developed and has been consistently improved over our 20+ years of sensor expertise, produces best-in-class sensor fusion. This claim is backed by customers who chose us for our distinct accuracy advantage. Additional features like calibration algorithms, contextual sensor fusion, and application specific features only add to that value. This sensor agnostic solution works with a variety of sensor types that enable a diverse set of applications.

### Holistic Smart Sensing



## Comprehensive Sensor Fusion & Algorithms

Application-specific solutions are created by assembling packages of algorithms that are customized to the needs of each unique application in order to provide the right solution with the lowest memory footprint.



## Key Benefits of Ceva MotionEngine

- **Dynamic Calibration** that adjusts for accelerometer and gyroscope bias changes over factors like time and temperature
- **Magnetic Interference Rejection** algorithms designed to ignore sudden changes in magnetic field
- **Sensor, operating system and processor independent**
- **Drivers and sensor management** written for a wide variety of inertial and environmental sensors for integration with:
  - Android™, Linux®, Windows®, macOS®, WebOS™
  - RISC-V, arm, Ceva DSP, other RISC-based processor architectures
- **Specialized algorithms** to cover various applications:
  - **Cursor Control** with Single Pixel Accuracy - software designed for in-air pointing applications for using with motion remote controls
  - **Gesture Recognition** - including flick, twist, flip, shake, in-air symbol recognition, virtual controls, tap, double tap, and in-ear detection
  - **AR/VR Stabilization and Predictive Head Tracking** - algorithms designed specifically to enhance and smooth AR/VR and 3D Audio user experiences
  - **Device Operation Mode Identification** - quickly determines the current orientation of a mobile computing device
  - **Personal Activity Tracking** - step counter and context detection, including walking, running, standing, in-vehicle, and on-bike
  - **Robust Motion Outputs** - including orientation, heading and tilt
  - **Orientation Compensation** - algorithms designed to ignore changes in orientation with respect to the movement of a cursor on a display
  - **Interactive Calibration** - boosts performance of lowcost sensors in terrestrial robotic applications
  - **Robotic Dead Reckoning** - Dead reckoning algorithm that offers a cost-reduced alternative to VSLAM or LIDAR solutions

## Distinct Software Packages

To better accommodate our customers, we have developed specialized software packages for the markets that we serve:

### Ceva-MotionEngine - Hear

In-ear and over-ear electronics like TWS, audio headsets, hearing aids, and AR glasses all have one thing in common: they can benefit from a gesture interface. But existing products have failures that frustrate users. MotionEngine Hear's tap gestures and in-ear detection make taking control of that audio easier and more fluid. On top of that, built-in activity classifiers and VAD add to a dynamic list of features that informs intelligent automated decision making, and our 3D head tracking enables immersive spatial audio.

### Ceva-MotionEngine - Smart TV

Did you ever wish you could more easily interact with your TV? The SmartTV package enables this by utilizing relaxed, instinctual hand motion and translating it intuitively on the screen. Movement (both physical and digital) feels natural with features like cursor control, orientation compensation, button motion suppression, and virtual controls.

### Ceva-MotionEngine - Robotics

Automated robots need to move intelligently through their spaces, and our algorithms ensure they can. After all, a robot's convenience is based on its autonomy. Our algorithms achieve precise heading with minimal drift. And with our interactive and dynamic calibration algorithms, robots can achieve great performance both right out of the box, and over time and changing temperature.

### Ceva-MotionEngine - Air

Handheld controllers deserve more than antiquated button-based interfaces. Cursor and gesture controls can be easily added to enhance interactivity. MotionEngine Air enables similar cursor capability as our SmartTV package, but also enables unique gestures (like twist, flip, pick-up) to help streamline workflows whether you're presenting, creating, or controlling.

### Ceva-MotionEngine - Mobile

As our desires for more "smart" devices has increased, so has their power consumption. MotionEngine Mobile delivers high performance, low power, sensor independent motion processing for mobile devices. This can be used to power motion applications, provide context awareness, activity tracking, and even pedestrian navigation. This software is versatile enough for smartphones, tablets, wearables, and IoT devices.

### Ceva-MotionEngine - Scout

Intelligent automated robots use complex Simultaneous Localization And Mapping (SLAM) algorithms to determine a robot's location. MotionEngine Scout determines a robot's position with the fusion of IMU, wheel encoder, and optical flow sensor data. This removes the reliance on cameras and LIDAR systems and adds robustness under crucial circumstances where typical visual sensors would fail.

### Ceva-MotionEngine - Hex

Users today often desire a more direct, touch screen-like experience with smart displays like PC monitors, commercial displays, and Smart TVs. The Hex package provides this by fusing position from UWB sensors and orientation from IMUs for an absolute pointing experience that isn't limited by the screen edge. Movement is smooth and natural with features like cursor control, orientation compensation, button motion suppression, and virtual controls.

## Hardware Product Line

Our best-in-class MotionEngine sensor fusion is available in a variety of hardware products seen below. Development kits are available for the BN0080, BN0086, and FSP200.

## BNO080/085/086

- **The BNO08X family (BNO080/085/086)** is a series of full System in Package (SiP) combining a 9-axis sensor and Cortex-M0+ processor running Ceva's MotionEngine Software
- **The BNO08X line** delivers
  - High quality heading and orientation outputs based on sensor fusion from both 6- and 9-axis sensing
  - Activity Classification for Stability, Tap, Steps, Walk, Run, Still, Significant Motion, Shake
- **The BNO08X line** is applicable to robotics, XR headsets and peripherals, 3D audio headsets, wearables, motion controllers, medical devices, fixed assets (antennas, lighting, etc), livestock tracking, and more
- If motion is involved, the BNO080/085 is likely able to help, especially if it requires a magnetometer and/or precise real-time tracking
- **The BNO085 and BNO086** have special compatibility with host-side libraries for fast magnetometer calibration and 6DOF XR
- **The BNO086** can utilize Interactive Calibration, an algorithm that minimizes heading drift in terrestrial robots.
- **I2C, SPI, and UART interface**



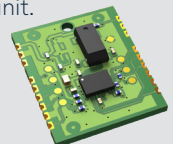
## FSP200

- **The FSP200** is a standard Cortex-M based microcontroller programmed with Ceva's MotionEngine software
- **The FSP200** delivers high quality sensor fusion outputs including heading and orientation when paired with a 6-axis sensor (accelerometer + gyroscope) from a pre-qualified list of sensors from multiple suppliers
  - Bosch BMI055
  - ST LSM6DSR
  - TDK InvenSense ICM20602A
- **The FSP200** is applicable to terrestrial robots, XR and 3D audio headsets, motion controllers, medical devices, and any other application that requires precise 6-axis heading and orientation measurements
- **UART interface**



## FSM300/305

- **The FSM300/305** is a turn-key module built using the BNO080 for easy prototyping and integration
- **The FSM300/305 delivers**
  - Higher accuracy heading and orientation over the BNO080/085 due to its per-device calibration
    - FSM300 calibrated about the yaw axis
    - FSM305 tri-axis calibrated (yaw, pitch, and roll)
  - Full 6- and 9-axis sensor fusion
  - Activity Classification for Stability, Tap, Steps, Walk, Run, Still, Significant Motion, Shake
- **The FSM300/305** is applicable to the fast development of robotics, XR headsets and peripherals, 3D audio headsets, wearables, motion controllers, medical devices, fixed assets (antennas, lighting, etc), livestock tracking, and more
  - The FSM300/305 is well suited for customers in the prototyping, early development, or low volume production when you need a calibrated unit. Customers are advised to switch to the BNO080/085 in their next iteration
- **I2C, SPI, and UART interface**



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