## Sensor Fusion

A typical mobile device has multiple sensors: at least one camera plus GPS, inertial sensors, and a compass. Given that individual tracking technologies -optical and non-optical—have distinct advantages and disadvantages, the best results are obtained when tracking makes use of the input provided by all available sensors. An obvious way to improve upon single-sensor tracking is to use multiple types of sensors simultaneously. On the one hand, such a combination of sensors in a hybrid tracking system increases the weight, cost, and power consumption of the resulting system, and requires additional calibration effort for the registration of the sensors with respect to one another. On the other hand, it provides for a superior overall system performance, which overcomes individual limitations.

In signal processing and robotics, the combination of multiple sensors is often called sensor fusion. This approach requires both sensor fusion algorithms and a software architecture to support multiple sensors.

### There are 3 Types of Sensor Fusions:

### 1) Complementary Sensor Fusion

Complementary sensor fusion occurs when multiple sensors supply different degrees of freedom. No interaction between the sensors is necessary, other than combining the resulting data. Of course, this combination can still be nontrivial, if the sensors are not synchronized and use different individual update rates. Such a situation requires at least some form of temporal interpolation or extrapolation. The most common use of complementary sensor fusion is to combine a position-only sensor with an orientation-only sensor to yield full 6DOF. For example, in a modern mobile phone, GPS delivers position information, while the compass and accelerometer deliver orientation data.

### 2) Competitive Sensor Fusion

Competitive sensor fusion combines the data from different sensor types measuring the same degree of freedom independently. The individual measurements are combined into a measurement of superior quality using some form of mathematical fusion. Redundant sensor fusion is a simple variant of competitive sensor fusion. When the primary sensor is delivering measurements, secondary sensors are ignored. Only when the operation of a primary sensor is not possible does a secondary sensor take over. For example, poor or intermittent GPS reception.

### 3) Cooperative Sensor Fusion

In cooperative sensor fusion, a primary sensor relies on information from a secondary sensor to obtain its measurements. For example, most modern phones contain assisted GPS (A-GPS), which speeds up the initialization of GPS measurements by deriving a position constraint from the ID of the cell- tower to which the phone has established a radio link. Likewise, GPS and compass technologies or accelerometers may be used as an index into a database of natural features, so that feature matching has a higher success rate. In a more general sense, cooperative sensor fusion can be described as any measurement of a property that cannot be derived from either sensor alone.

## Optical Tracking

- Optical tracking is a means of determining in real-time the position of an object by tracking the positions of either active or passive infrared markers attached to the object.
- Optical tracking systems make use of visual information to track the user. There are a number of ways this can be done. The most common is to make use of a video camera that acts as an electronic eye to “watch” the tracked object or person. Computer vision techniques are then used to determine the object's position based on what the camera “sees.
- Illumination The first aspect of optical tracking to be discussed is the nature of the light. We must distinguish approaches that rely on naturally occurring, passive illumination and those that rely on active illumination.
- Passive Illumination Passive illumination comprises light sources that are not an integral part of the tracking system. Passive illumination comes both from natural light sources, in particular the sun, and artificial light sources, such as ceiling lights. Like humans, conventional cameras see light in the visible spectrum (380-780 nm) reflected off objects in the environment. Using a conventional digital camera with passive illumination is the simplest approach to optical tracking in terms of physical setup.
- Active Illumination Active illumination overcomes the dependence on external light sources in the environment by combining the optical sensor with an active source of illumination. Because active illumination in the visible spectrum changes how the user perceives the environment and is therefore disturbing, a popular approach is to rely on infrared illumination
- Structured Light Structured light goes one step further than active illumination with unstructured light sources by projecting a known pattern onto a scene.
- The source of the structured light can be a conventional projector or a laser light source. The observed reflections are picked up by a camera and used to detect the geometry of the scene and the contained object.