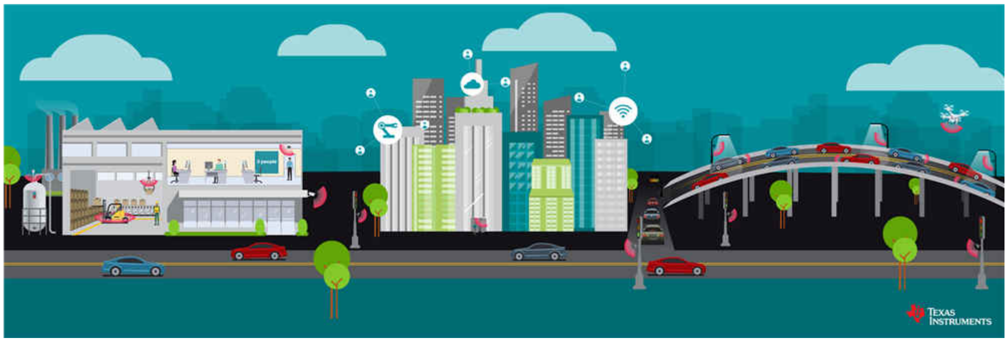
mmWave Fundamentals: Range, Velocity and Angle

RFerguson



Large dishes pointed towards the sky for air traffic monitoring or handheld devices used by police or baseball scouts to track speeds of cars and baseballs – that's what many people think about when the word "radar" is used. Today, interest in its use has exploded far beyond these applications, particularly in the automotive and industrial markets. However, due to the technical limitations of silicon germanium (SiGe), many radar solutions are both bulky and costly, with a variety of discrete components implemented separately, making it both difficult and expensive to leverage radar in new applications.

With the recent introduction of TI's family of highly integrated radar sensors, millimeter wave (mmWave) radar sensors no longer face these limitations. TI's AWR1x and IWR1x solutions support a variety of automotive and industrial applications, including short- through long-range radar, level sensing, traffic monitoring and more. With accuracy up to 3x that of competing solutions, TI's mmWave radar sensors provide the crucial range, velocity and angle measurements essential to these applications.

Range

The fundamental concept in radar systems is the transmission and reflection of an electromagnetic signal. This process reveals the range (distance) of an object. However, there is more to measuring range than simply the accuracy of the measurement. Range resolution is the ability to distinguish between two closely spaced objects. For example, high-range resolution enables the system to distinguish between a car and a pedestrian standing next to it, both from the car's perspective, as well as in traffic-monitoring applications. High-range resolution also helps improve the minimum measurable distance, which means that the system can detect objects closer to it. This is important for automotive applications like park assist, for which the detection of nearby objects is crucial. It's also necessary in industrial settings, allowing more accurate measurement of fluid levels closer to the top of a tank, for example.

Velocity

Velocity, of course, is the speed at which an object is moving toward or away from the mmWave radar sensor. This is simple enough in a controlled setting. But no one has ever said that industrial and automotive settings are simple or controlled. For example, a car must be able to not only distinguish between the car directly in front of it and a cyclist in the next lane, but also determine their respective velocities in order to predict the motion of each.

Because velocity enables the sensor to process whether a detected object is moving or stationary, this measurement helps the system calculate how much time it has to make a decision about an approaching object. For example, in an industrial setting, A robot approaching another robot or person is able to factor the velocity of the object into its decision-making process, rather than basing decisions solely on the proximity.

By virtue of their small wavelengths and coherent detection, TI's mmWave sensors can measure very small changes in displacement and velocity and even the vibration pattern of movements. Vibrating or rotating objects induce measurable periodic Doppler shifts, producing valuable data for several different applications. For example, the vibration pattern of rotating machinery such as electric motors can help with performance monitoring and early fault detection. The unique, periodic movement of the human limbs while walking and running can help distinguish a person from other objects such as a car or a cyclist. These sensors are sensitive enough that they can even identify and classify different hand gestures. By measuring body-surface displacements as small as 0.2mm, these sensors can even extract the breathing rates and heart rates of humans without physical contact, with future potential applications such as monitoring vital signs or detecting a child or pet left in a hot car.

Angle

A final important element is a radar's ability to recognize angle. Being able to accurately calculate the angle of arrival is crucial to a radar system's ability to predict an object's path, which is the difference between an industrial forklift sensing that a worker is likely to cross its path rather than pass behind it.

Angle, velocity and range are three crucial measurements a radar system must be able to accurately combine in order to detect where an object – such as a pedestrian, car or animal – is, but more importantly, predict where it will go. Because of the high degree of integration in TI's family of mmWave radar sensors, these devices are able to deliver all three of these measurements with the high degree of accuracy needed in automotive and industrial applications. We'll dive more deeply into each measurement in subsequent posts.

Additional Resources:

- Learn more about mmWave sensors in the "Fundamentals of millimeter wave sensors" white paper
- Learn how "TI's smart sensors enable automated driving" in our white paper
- See how TI is "Giving cars advanced vision through mmWave sensors" on our blog
- See how TI is "Bringing new intelligence to industrial applications with mmWave sensors" on our blog