Michael Tang

Imaging and Localization Individual Topic Review

C01 - See through walls with Wi-Fi Adib and Katabi propose that detection of moving objects behind walls can be implemented much more cheaply than previous attempts. To that end, they implement Wi-Vi, a behind-wall movement detection device based on only a 3-antenna MIMO radio. Objects can be detected behind non-metal walls by looking for reflection of waves that make it past the wall to hit the objects. The main problem to deal with is that this reflection is magnitudes fainter than the reflection from the wall. While previous implementations attempt to surmount this by sending super-wide wavelength signals or using nodes behind the wall, Wi-Vi uses transmission in multiple stages to null returning waves from the wall and enable detection of behind-wall reflections. Adib and Katabi concede that the nulling method is still imperfect, but point out that the much lower cost and ability to null more than one surface are very worth it. They report from testing of human subjects enclosed in real home and office spaces a promisingly high accuracy rate of movement detection and very good gesture detection as well. C03 - Object Recognition and Navigation using a Single Networking Device Zheng et al. explore the cost and mobility benefits of using 60GHz radios for object imaging and detection purposes. As autonomous technologies such as drones and self-driving cars become more commercially prevalent, a current critical barrier to mainstream market is the heavy cost of present detection schemes such as mmWave and LIDAR. To demonstrate a promising solution, they implement Ulysses, a practical environmental imaging device over small 60GHz networking radios. Using narrow beamforming Ulysses is able to sense specular reflection, which can be leveraged to maintain a live image of its surroundings as well as surface detail through strength and angle of reflection. This paves the way for safe navigation with cm-accurate obstacle detection meters away. There are limitations, such as interference from multipath reflection and device rotation, but they are small and improvable. They conclude that 60GHz is a promising path to cheapen and mobilize autonomous technology. D04 - COIN-GPS Nirjon et al. attempt to surmount the Achilles' heel of traditional GPS: the inability to acquire satellite connection and track location indoors due to already weak signals coming from orbit satellites being weakened beyond recognition by multipath and other effects experienced indoors. To this end they create Cloud-Offloaded Instant-GPS to enable locational tracking indoors. Various characteristics of COIN-GPS that allow for much improved detection indoors include attenuation to signals that pass through more allowing barriers of the building like glass and thus experience less path loss, as well as more advanced correlation algorithms for satellite location and offloaded computation to account for the Doppler Effect rather than constant retransmission. Upon implementing COIN-GPS using a moving wide antenna and a laptop in several locations, Nirjon et al. find that they are able to calculate indoor location with a 4-12m error at best - still able to differentiate between different sections of a store, and to provide good indoor mapping. D06 - Accurate Outdoor AP Location Using Smartphones Zhang et al. point out the increasing need for outdoor access to Wi-Fi Access Points (APs), for purposes such as offloading of cellular data streaming for carriers. In preliminary findings they conclude that the biggest obstacle to outdoor AP detection by a smartphone is the user's position and orientation relative to the AP. To that end Zhang et al. prototype Borealis, a system to provide directional guidance to users to get optimal AP connection. Borealis measures signal strength profile to detect the body obstacle and estimate direction towards the nearest AP. Feedback can then be provided to the user so that they may move closer and find connection. The prototype, built on Android with OS-level modifications to speed estimation of direction, performs very effectively especially compared to other similar systems. Summary This learning area taught me first and foremost that as mobile technologies advance and certain, already known communications and signaling methods get cheaper, new solutions previously unheard of become possible. All four of these papers were focused on ways to surmount obstacles of early communications technology that previously were only approached with high-tech, brute-force solutions. All four propose more efficient implementations that simply require additional manipulation of already implemented infrastructures, rather than an extensive suite of new hardware. It shows that much of the sci-fi future we dream of can be based on what we already have, with more insight into the physics.