Research Topics
Surveying & Geospatial Engineering (SAGE) Group
School of Civil & Environmental Engineering

Multi-GNSS studies

Positioning, navigation and timing (PNT) capabilities are rapidly gaining importance in modern societies. Global Satellite Navigation Systems (GNSSs), such as the Global Positioning System (GPS), have a wide variety of uses, including land, air and maritime navigation; military and security-related operations; agriculture, mining and construction; geodesy, surveying and mapping; machine automation and robotics; transportation; emergency response and disaster management; financial services; timing and personal location-based services. These varied applications use different receiver instrumentation, infrastructure, operational procedures and measurement processing algorithms. The next few years will see the launch of many additional navigation satellites broadcasting several new signals, resulting in a significant of trackable satellites and signals. These next generation GNSSs include the US's modernised GPS and planned GPS-III constellations, Russia's GLONASS, Europe's Galileo system and China's BeiDou system. In addition, several Regional Navigation Satellite Systems (RNSS), such as India's IRNSS and Japan's Quasi-Zenith Satellite System (QZSS), and Space Based Augmentation Systems (SBAS), will broadcast extra signals for PNT users. SAGE researchers have made important contributions to the development of GNSS technologies, measurement processing algorithms and applications.

Satellite navigation receiver design & signal processing algorithms

Receiver design is a challenge as the number of GNSS/RNSS constellations expand and new navigation signals are broadcast to users. Current research achievements in GNSS/RNSS receiver research topics include RF and baseband algorithms associated both with the original GPS technology and the unique features of new signals from modernised GPS and other GNSSs/RNSSs, innovative designs for signal acquisition and tracking and the integration of several systems into one receiver. This research is conducted within the "Satellite Navigation and Positioning" (SNAP) Lab, an inter-school research laboratory in partnership with the group led by Prof Andrew Dempster in the School of Electrical Engineering & Telecommunications. This continues the two decades of satellite-based research in the original "SNAP" Lab established by Prof Chris Rizos. This research uniquely takes advantage of several generations of the SNAP-developed "Namuru" GNSS receivers. Other topic areas include: GNSS radio-frequency interference detection & geolocation; RF/antenna studies; weak GNSS signal tracking; improved signal tracking algorithms; and non-PNT applications of GNSS.

Multisensor integration systems, algorithms & applications

Multisensor integration is concerned with the development of technologies and algorithms for navigation (or location-determination) sensor systems that can operate in all conditions, and especially those where GPS/GNSS cannot be used. The research starts with the classical combination of GNSS with an Inertial Navigation System (INS), comprising several orthogonally-mounted accelerometers and gyroscopes, to provide sensor platform positioning and orientation information. SAGE is researching the use of multisensor systems for Unmanned Aerial Vehicles (UAVs) and terrestrial platforms, including low-cost MEMS (microelectromechanical) INS. Our multisensor integration research has been extended to include vision/image sensor and terrestrial positioning sub-systems, as well as quality control processes within navigation systems.

Personal & indoor positioning/navigation

Personal navigation is a significant engineering challenge as position information need typically to be provided in indoor environments, which are unsuited for GNSS or even GNSS/INS systems. "Pedestrian navigation" include personal applications such as for emergency service personnel inside buildings and the blind and visually impaired, using a range of sensor/positioning technologies, either on their own or in combinations, including WiFi-based positioning, RFID, vision and inertial sensors, and mobilephone-based positioning. "Locata" is an innovative high accuracy positioning technology that can be used on its own or in combination with GNSS. Locata is an Australian invention that has been described as a 'local GPS' because it can satisfy GPS performance requirements even where GPS/GNSS cannot operate, using terrestrial signal transmitters. Locata applications include precise indoor positioning, positioning in deep open-cut mines and in airborne applications, as well as providing timing information, all scenarios where GNSS may be unavailable due to jamming or obstructed satellite signals.

Precise GNSS positioning technology & applications

A wide range of applications are investigated, including surveying, geodesy, structural monitoring, geo-referencing of mobile mapping platforms, support for robotics and machine guidance, and future automotive use in cooperative positioning in support of advanced intelligent transport systems (ITS) applications. All are characterised by the use of measurements, data processing algorithms and operational procedures that can deliver centimetre-level accuracy – far better than the developers of GNSSs ever envisaged. SAGE research includes: measurement modelling & algorithm design; multi-GNSS systems; real-time carrier phase-based positioning; Precise Point Positioning; differential positioning; impact of augmentation services (via web & satellite links); design of permanent reference station networks & protocols; multisensor integration.

Geodetic infrastructure & analysis

"Geodesy" supports both the geosciences, as well as the surveying, mapping and geospatial user communities. Geodesy defines and maintains the critical reference frames, including the International Terrestrial Reference Frame (ITRF). Geodetic GNSS is closely linked to the realisation of the ITRF, as well as providing the everyday means of determining coordinates in the ITRF using special high accuracy GNSS techniques. The ITRF is the basis for a nation's mapping/geospatial datum. Increasingly such datums are realised by permanent, continuously-operating, reference stations (CORS) of GNSS receivers located at stable sites. SAGE research includes: design of the National Positioning Infrastructure (NPI); the new geodetic datum for Australia and New Zealand; issues related to dynamic datums; the implementation of NPI; ground deformation monitoring & modelling; user datum requirements; transformation models; precise GNSS products from CORS network data processing; contributions to international geodetic projects & initiatives.

Precise surveys for deformation & construction

Surveying instrumentation such as Total Stations (TS – high accuracy angle & distance measuring devices), digital levels and Terrestrial Laser Scanners (TLS) are used in a variety of construction, mapping and geodesy applications. To assure the highest accuracy in measured and derived quantities, high level expertise in measurement modelling, instrument calibration, atmospheric refraction models, and measurement adjustment & quality assurance is required. SAGE research includes: performance analysis of TS & TLS instrumentation; control network adjustment; advanced surveying applications (deformation monitoring, mining/tunnelling, etc); and GNSS-RTK.

Earth observation systems

"Earth observation" (EO) is amongst the fastest growing geospatial/mapping technology fields. A variety of imaging sensors (radar, optical, multi- and hyper-spectral) and remote measurement systems (laser scanning, radar altimetry, etc) can be installed on different platforms (satellite, aerial or vehicle-mounted). EO systems remotely sense many environmental parameters. They can be used in image processing systems to generate maps or metrically-corrected images, to derive terrain or 3D city models, or to map buried geophysical features. Traditional applications include environmental monitoring, such as land use, vegetation cover mapping, atmospheric and geosphere sensing, and geophysical investigations. EO systems are also increasingly used in geohazard studies, natural disaster assessment and emergency response management. Traditional photogrammetry and hi-resolution optical and infra-red imaging systems continue are also important geospatial data acquisition technologies. SAGE research areas include sensor calibration; direct geo-referencing of sensors & automated feature extraction; as well as those related to a variety of mapping/imaging applications, including the use of UAVs.

Remote sensing technologies & applications

Radar remote sensing is a critically important satellite EO technique for a wide range of applications. In particular there has been a significant growth in the use of synthetic aperture radar images for such purposes as monitoring vegetation and land use, biomass and soil moisture, water surfaces and flooding, pollution at sea, ship detection, terrain mapping and ground deformation measurement. Prof Linlin Ge's research group is particularly focused on this technology, and an important initiative is "LIME" – Laboratory for Imaging in the Mining Environment.

Lidar, mapping & geoinformation management systems

Lidar – Light Detection & Ranging – is a geospatial technology that generates massive volumes of "point cloud" data, consisting of 3D coordinates of points, together with reflection quality information. The combination of digital imaging and laser scanning is revolutionising the way geospatial information is acquired for rapid mapping of transport corridors, the urban landscape and even inside public buildings. SAGE is engaged in several research topics including: the sophisticated analysis of lidar sensor data; the development of applications-specific algorithms for terrain & forest mapping, 3D city modelling; rapid mobile mapping of transport corridors & engineering structures; and digital photogrammetry. Geographic Information System (GIS) technology is used to manage, analyse and visualise geospatial information – information that has both a 'spatial' and 'text' component. The "geoinformation" comes from many sources: new data acquisition systems as well as historical digital data sets.