

# Robot Localisation and Map Building: Closed Form Solutions, Feature Detection & Probabilistic Map Representations

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The aim of this seminar is to provide an introduction to the research carried out in NTU towards fully autonomous robot navigation. In the first part, the estimation of problematic sensor biases in the estimation theoretic map aided localization (MAL) problem are considered. Closed form solutions for the convergence, lower bound uncertainty and observability will be presented. The second part will present the convergent detection of features in multi-scale space, applied to range data. The final part will demonstrate the inclusion of target detection attributes into map representations.

**1. Closed Form Solutions to Sensor Bias Correction for MAL.** Simultaneous Localization and Map Building (SLAM) and Map aided localization (MAL) are very effective techniques deployed extensively in robot navigation tasks. However, biases and drifts in both exteroceptive and proprioceptive sensors adversely impair correct localization (in MAL) and also impair map building (in SLAM). More specifically, accumulated bias errors in the sensors cause the algorithms to diverge and produce inconsistent and inaccurate results.

An approach to overcome these problems has been to explicitly estimate the bias parameters concurrently with the vehicle state using an augmented state space approach. This talk summarises a rigorous theoretical study on the issues of observability and convergence, their interrelations and effects on the algorithm's performance. The results are verified experimentally using a MAL algorithm, utilizing a low cost inertial navigation sensor suite.

**2. Convergent Detection of Dominant Features from Noisy Range Data in Multi-Scale-Space.** Laser range finders are currently one of the most common sensors used in robotic navigation. Successful feature extraction is largely dependent on efficient noise reduction and proper segmentation. Most of the existing noise reduction and data segmentation algorithms are only suited to image data. Therefore, an adaptive smoothing algorithm, with a model based mask, within a scale space framework is proposed for range data. The algorithm presented smoothes range data in multi-scale space, and conforms to the anisotropic diffusion concept, so that dominant features are extracted, and no artificial features are created. Segmentation and smoothing in a proper scale, with real laser range data will be demonstrated, for robot navigation.

**3. Including Probabilistic Target Detection Attributes into Map Representations.** This part unifies the problems of probabilistic map building and signal detection, and suggests that both processes should be considered together. To facilitate an analysis of the range detection process, millimeter wave radar (MMWR), which is able to provide complete received power-range spectra for multiple targets down-range, is considered. Evidence theory is introduced to model and update successive observations in a recursive fashion, to achieve probabilistic maps based on occupancy, emptiness and ignorance.

## **Associate Professor Martin D. Adams**

Dr. Martin Adams obtained his first degree in Engineering Science at the University of Oxford, U.K, in 1988 and continued to study for a D.Phil at the Robotics Research Group, University of Oxford, which he received in 1992. He continued his research in autonomous robot navigation as a project leader and part time lecturer at the Institute of Robotics, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland. He was employed as a guest professor and taught control theory in St. Gallen (Switzerland) from 1994 to 1995. From 1996 to 2000, he served as a senior research scientist in robotics and control, in the field of semiconductor assembly automation, at the European Semiconductor Equipment Centre (ESEC), Switzerland. Since 2000, he has been employed as Associate Professor at the school of Electrical and Electronic Engineering, NTU, Singapore. Dr. Adams is the author of *Sensor Design, Modelling and Data Processing for Autonomous Navigation*, a book released by World Scientific Publishers in 1999. He has published many articles in top ranking robotics journals and conferences, as well as various book chapters. He has been principle investigator of two robotics projects at NTU, and is currently leading a third, large research project which is coordinating researchers from NTU, NUS, and local industry in providing autonomous cleaning and surveillance vehicles to Sentosa, Singapore's largest theme park.