LONG RANGE OUTDOOR RGBD AND IMMU ODOMETRY

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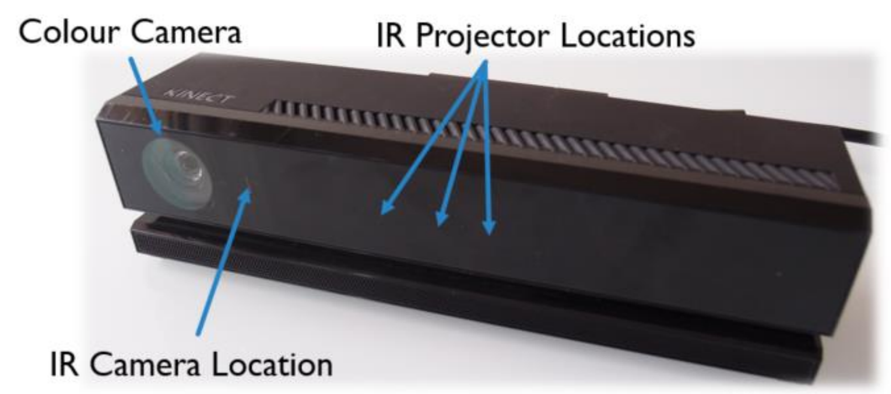
INTRODUCTION



Autonomous mobile robots require localisation to carry out their functions. High precision GPS units may be unsuitable due to cost, or operation in GPS-denied environments. Visual odometry is one solution to this problem which estimates the position of a camera by aligning image data.

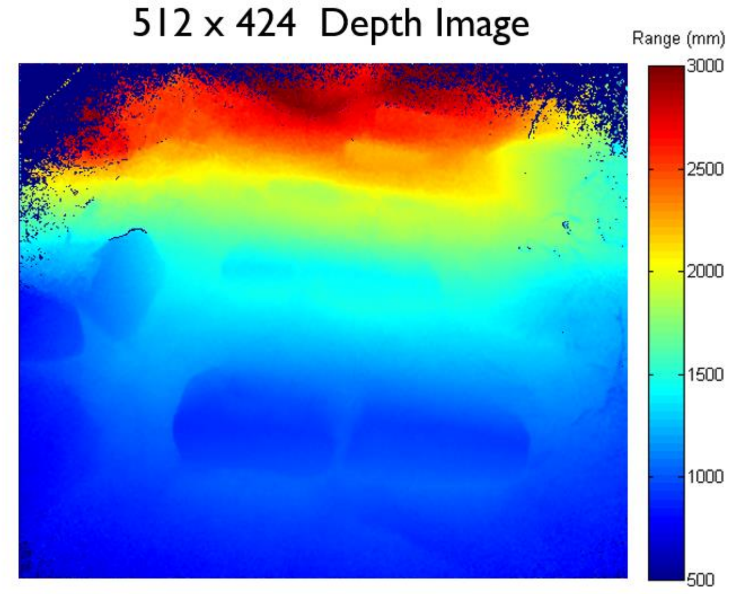
Red-Green-Blue-Depth (RGBD) cameras, like the Kinect for Windows shown above, capture colour and depth data simultaneously by measuring the return time of flight of projected infrared (IR) radiation. An example output from the Kinect is shown below. In this thesis an RGBD odometry system is presented which fuses visual and depth odometry with Attitude Heading Reference System (AHRS) orientation computed using an Inertial and Magnetic Measurement Unit (IMMU). These cameras have previously been used only over shorter distances and confined to indoors due to IR radiation interference from sunlight.

Research Goal

To develop an RGBD odometry system capable of being used over long distances of outdoor terrain.

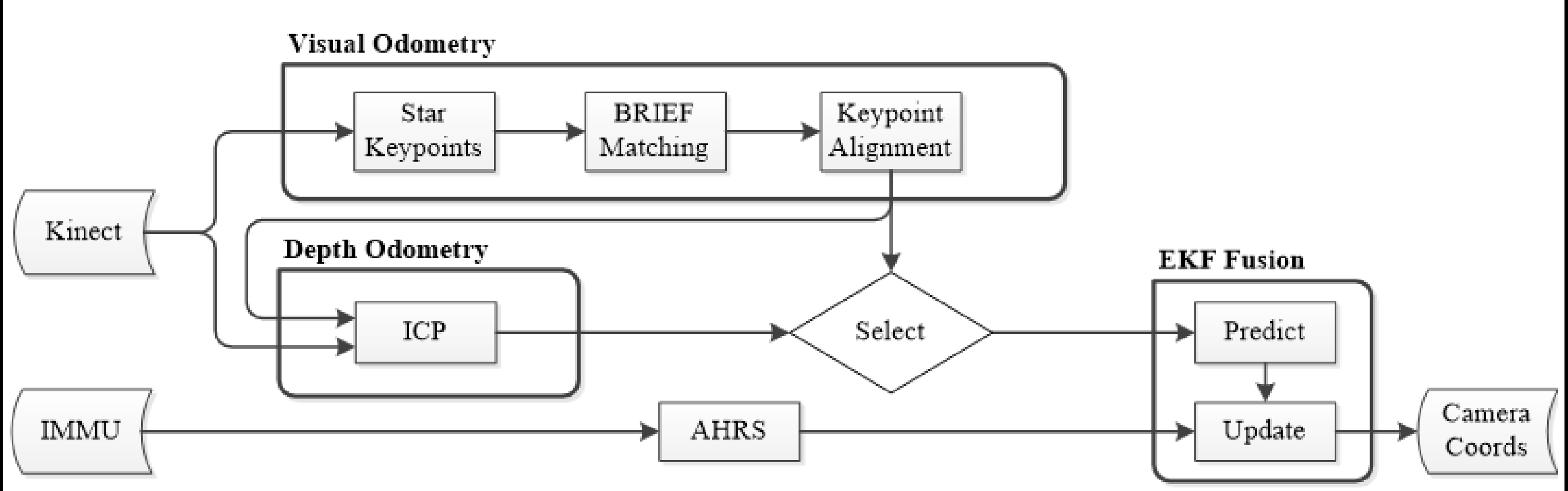
1920 x 1080 Colour Image

512 x 424 Depth Image



ODOMETRY SYSTEM

The odometry system combines visual and depth odometry techniques fused with an AHRS. The visual odometry system is a keypoint based tracker which finds keypoints in images using the Star keypoint detector, and matches them across images using the Binary Robust Independent Elementary Features (BRIEF) descriptor. Keypoints can be projected to 3D using the Kinect depth camera and aligned to produce the visual odometry estimate.



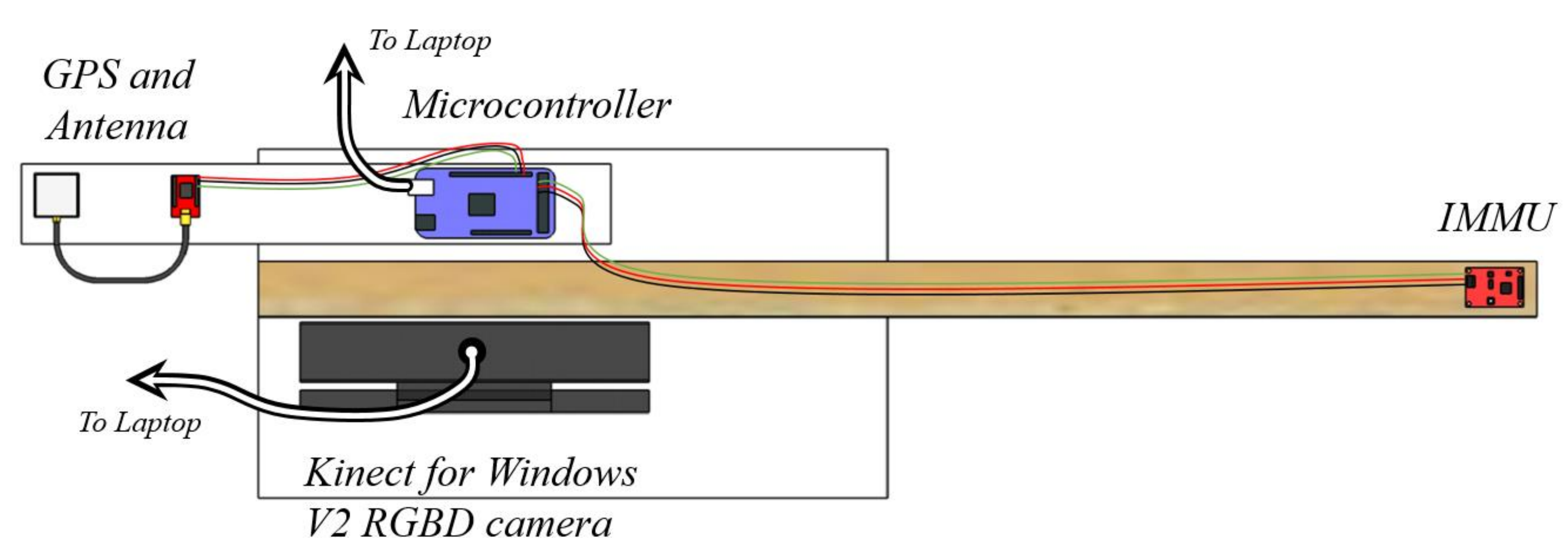
Depth odometry is performed using Iterative Closest Point (ICP) to align dense point clouds projected from the depth image, initialized by the visual estimate. The two odometry types are selected between depending on terrain using a planar fit metric; when the residual of a planar fit is small the ground is mostly flat and the visual estimate is used, otherwise the dense depth alignment is used.

The IMMU computes an orientation relative to a North-East-Down coordinate system using the AHRS, which is fused with the selected odometry estimate using an Extended Kalman Filter (EKF).

HARDWARE IMPLEMENTATION

To use the Kinect camera outdoors requires overcoming IR radiation interference from sunlight. This is achieved with a translucent shield shaped as a truncated pyramid, or frustum, which transmits some visible light for the colour camera and blocks IR for the depth camera.

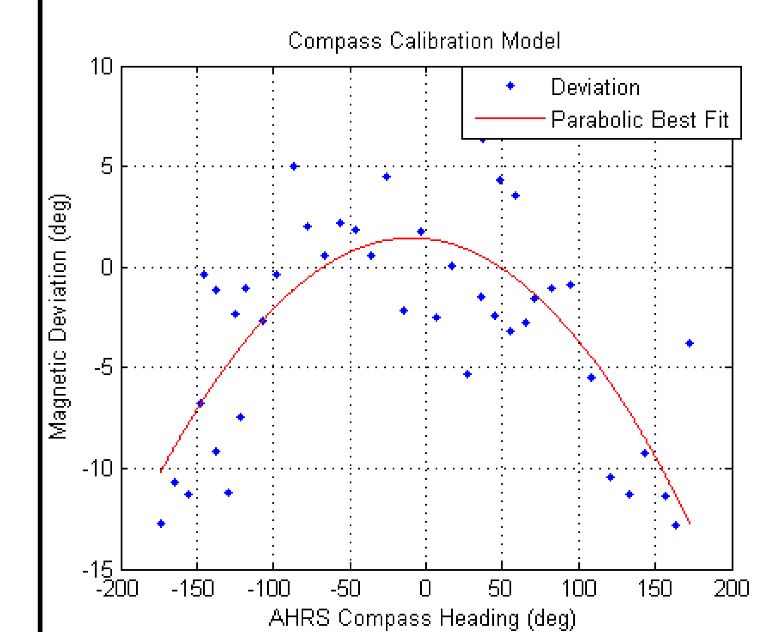
The Kinect assembly includes all the key hardware components, including the camera itself, a low-cost IMMU, a GPS unit to provide a reference for the path travelled, and a microcontroller which collects and timestamps data from the IMMU and GPS.

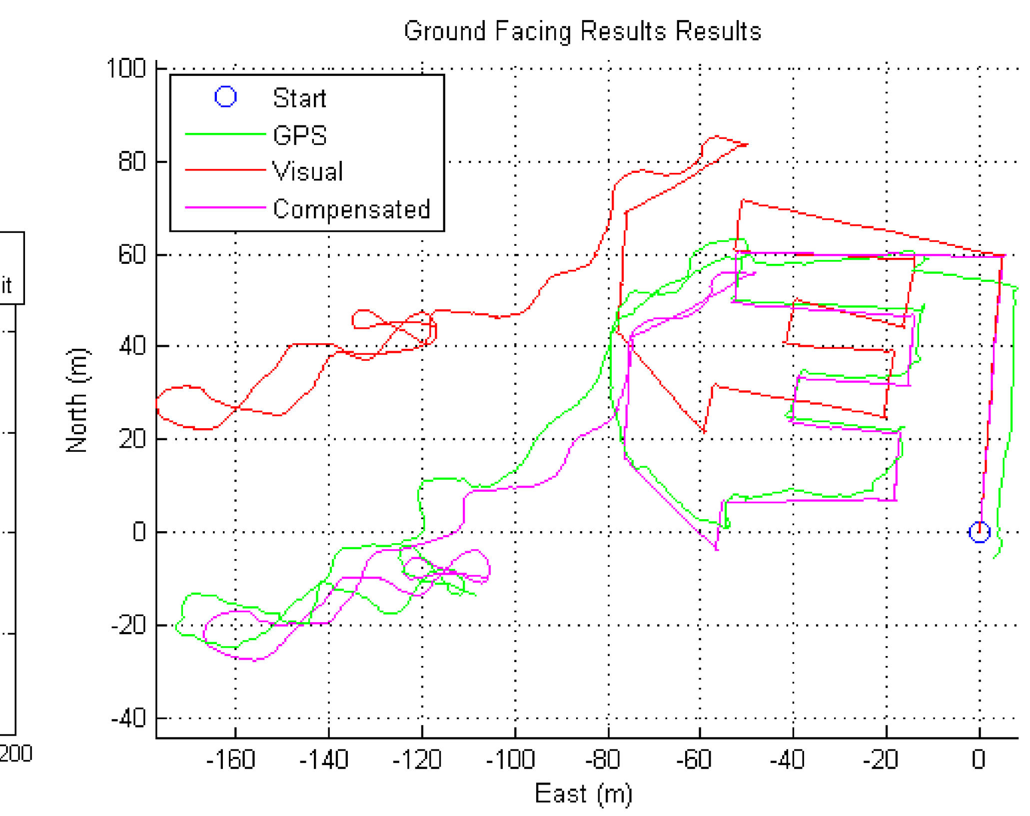


EXPERIMENTAL RESULTS

The system was tested in two configurations, one using the frustum shield outdoors at midday, with the camera ground facing, and the other using only the Kinect assembly hand-held in late afternoon shade.

Ground Facing Camera





The ground facing test was conducted on short, flat grass, so visual odometry was chosen over depth. The initial result showed drift due to the magnetic distortions of the frustum trolley. This was compensated for by computing magnetic deviation of the compass as a function of bearing. The compensated path successfully tracks the GPS. On straight line segments the linear error is between 1-3%, while position error at the most Western point is 6.5m or 1.2% of the 550m travelled.

Hand Held Camera

The hand-held test followed a rough bush track. In low light, motion blur caused the visual estimate to drift significantly. However the depth odometry, selected at most steps due to the presence of depth features like rocks and trees, accurately tracked the GPS path. A final position error of 20.3m was achieved over the 600m path, or a 3.4% error.