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Autonomous Surface Sample Acquisition for Planetary and Lunar Exploration

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Surface science sample acquisition is a critical activity within any planetary and lunar exploration mission, and our research is focused upon the design, implementation, experimentation and demonstration of an onboard autonomous surface sample acquisition capability for a rover equipped with a robotic arm upon which are mounted appropriate science instruments.

Images captured by a rover stereo camera system can be processed using shape from stereo methods and a digital elevation model (DEM) generated. We have developed a terrain feature identification algorithm that can determine autonomously from DEM data suitable regions for instrument placement and/or surface sample acquisition. Once identified, surface normal data can be generated autonomously which are then used to calculate an arm trajectory for instrument placement and sample acquisition.

Once an instrument placement and sample acquisition trajectory has been calculated, a collision detection algorithm is required to ensure the safe operation of the arm during sample acquisition. We have developed a novel adaptive 'bounding spheres' approach to this problem. Once potential science targets have been identified, and these are within the reach of the arm and will not cause any undesired collision, then the 'cost' of executing the sample acquisition activity is required. Such information which includes power expenditure and duration can be used to select the 'best' target from a set of potential targets. We have developed a science sample acquisition resource requirements calculation that utilises differential inverse kinematics methods to yield a high fidelity result, thus improving upon simple 1st order approximations.

To test our algorithms a new Planetary Analogue Terrain (PAT) Laboratory has been

created that has a terrain region composed of Mars Soil Simulant-D from DLR Germany, and rocks that have been fully characterised in the laboratory. These have been donated by the UK Planetary Analogue Field Study network, and constitute the science targets for our autonomous sample acquisition work. Our PAT Lab. terrain has been designed to support our new rover chassis which is based upon the ExoMars rover Concept-E mechanics which were investigated during the ESA ExoMars Phase A study. The rover has 6 wheel drives, 6 wheels steering, and a 6 wheel walking capability. Mounted on the rover chassis is the UWA robotic arm and mast. We have designed and built a PanCam system complete with a computer controlled pan and tilt mechanism. The UWA PanCam is based upon the ExoMars PanCam (Phase A study) and hence supports two Wide Angle Cameras (WAC - 64 degree FOV), and a High Resolution Camera (HRC - 5 degree FOV). WAC separation is 500 mm. Software has been developed to capture images which form the data input into our on-board autonomous surface sample acquisition algorithms.