Preliminary Study of Stereo Vision with Fisheye Lens Cameras on Asteroids. Yoshio Hamada[1], Hirohide Demura[1], Naru Hirata[1] and Noriaki Asada[1], [1]Department of Computer Software, University of Aizu, Ikki-machi, Aizu-Wakamatsu City, Fukushima 965-8580, Japan, m5101122@u-aizu.ac.jp.

Introduction: This research shows advantages of stereovision with fisheye lens cameras for a rover, a lander or close-observation missions to asteroids, and a method to determine three-dimensional locations of objects on the asteroid surface space from stereo pair images taken by a fisheye lens camera. This technique is proposed as a method for the autonomous navigation of a rover or a lander on an asteroid, thus all data processing have to be completed by an onboard computer on a spacecraft. Most of stereovision systems simply use two telescopic cameras set in parallel with each other, in which there are problems for determination of the locations of objects around a rover or a lander on the asteroid surface, or positioning of the spacecraft; the onboard camera cannot cover all around the landing spacecraft without a gimbal mechanism or multiple cameras because of the narrow field of view of the telescopic lens. Concerning limited weight, space, and electric consumption of the small spacecraft, heavy moving mechanisms such as a gimbal should be avoided. We propose a stereovision system with a cluster of fisheye lens cameras as an alternative idea. Preliminary results of concept studies and software developments of the system are reported here.

Hardware and Software Components of the System: Hardware of the system consists of two or more fisheye lens cameras that are fixed on the spacecraft. As the field of view of a fisheye lens is over 180 deg, the single set of the cameras can observe all around the spacecraft without any gimbals or any moving mechanisms, and without image mosaicing by onboard data processing. This concept ensures robustness and free-of-maintain of the hardware. A side effect of this con-figuration is that operation of the spacecraft is very simple because of all fixed components. This specification is also applicable to omnicamera easily.

In case of a fisheye lens cameras system, the algorithm for determination of three-dimensional locations of the objects should be modified from the common stereovision technique in spite of a simple hardware.

The software determines the location of the objects in the three-dimensional space from stereo pair images taken by the fisheye lens cameras. The method is called Matching processing. A point *A* in Image1 place is a projection of a point whose axes are expressed in Fig 1. This matching software searches a pixel corresponded to the point *P* in the other image, Image2. To reduce processing time and the number of mismatching, searching area should be limited on the line. This line is referred as the epipolar line, which is originally defined in the discussion in the classical study on stereovision, and now expanded to the case for fisheye lenses. The direction from the lens1to the object *P*, θ and ϕ, can be calculated from the location of P in the image coordinate and the information of projection of the fisheye lens (Fig. 1) [1]. While the actual distance from the lens1 to the *P* is unknown, *Pi* is defined as a candidate object on the line where *P* exists. Its coordination is expressed as *Pi* (ri, θ, ϕ). The point *Bi* in the Image2 is a projection of *Pi* onto the Image2, and the continuing track of *Bi* corresponds the epipolar line (Fig. 2) [2]. This software should take distortion of fisheye lenses, while usually matching algorithms don't consider distortion of lenses. We use the θ and ϕ coordinate system in the matching window for distorted images in stead of the rectangular coordinate (Fig. 3). Correlation factors are calculated from pairs of pixels in the both images, which are corresponding in this coordinate. After that the highest value of correlation gives the best matching point of *Bi*, as *B*, corresponded to *P*.

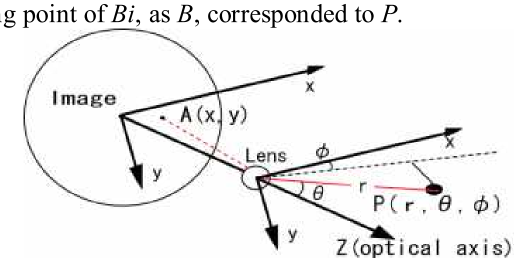

Fig 1: P (θ, ϕ) are calculated from A (x, y)

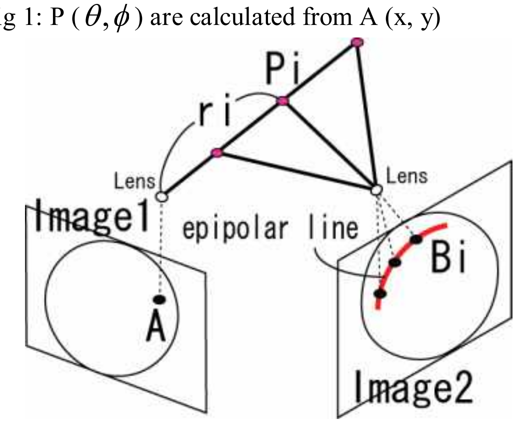

Fig 2:A(θ, ϕ) is known and *ri* is estimated. Matching A and Bi(θ, ϕ) which is derived from Pi (θ_i, ϕ_i, r_i).

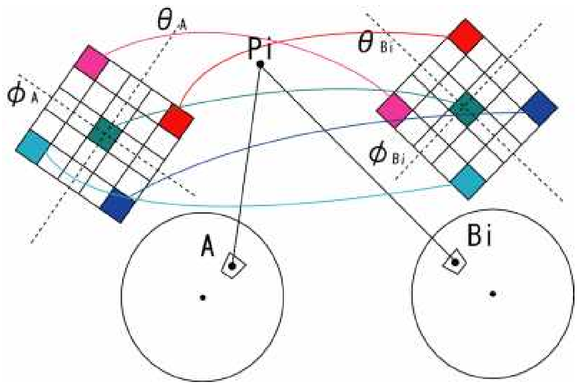

Fig 3: Image of Matching Window. The figure of marching window is depended on the target object θ and ϕ.

Summary: A stereovision system with fisheye lens cameras is proposed as a method for onboard navigation of an asteroid rover or a lander. This system doesn't require any moving mechanism, and ensure robustness. Algorithm for determination of the location of objects in the fisheye stereo-pair image is also proposed in considering large distortion of a fisheye lens camera image of the objects. This system should be the best matching in strabismus for a light-weight rover or a lander for the asteroid exploration.

References: [1] Toshirou. Kishikawa. (2004) Introduction to optical. [2] Gou. Jo, and Saburou. Tsuji. (2004) 3-dimentional vision.