RESULTS OF HIGH-DEFINITION TELEVSION SYSTEM (HDTV) ON BOARD SELENE (KAGUYA) . R. Honda[1], J. Yamazaki[2], S. Mitsuhashi[2], J. Tachino[3], M. Yamauchi[4], M. Shirao[5], [1]Kochi University, Akebono-cyo 2-5-1, Kochi, JAPAN, 780-8520 (honda@is.kochi-u.ac.jp) , [2] NHK (Japan Broadcasting Corporation), [3] NHK Engineering Service, [4] NHK Mito Broadcasting Station, [5]Planetary Geological Society of Japan

Introduction: High Definition Television System (HDTV) on board KAGUYA/SELENE is the camera system composed of a wide angle camera (HDTV-WIDE) and a telephoto camera (HDTV-WIDE), that aims to acquire the moving images of the moon and the Earth from the moon for the public outreach and the broadcasting. HDTV has succeeded in obtaining the moving images of the Earth rising from the moon and setting to the lunar horizon and other prominent features on the lunar surface. The data obtained amounts to 1.37 GB as of the end of November, 2008, and the instrument is kept in a good condition after 16 month operation in the space .This paper reports the current status of the HDTV, recent data obtained, and ongoing data analysis of HDTV images, in particular, the creation of digital elevation model (DEM) from the moving images.

Specification of HDTV: The field of view (FOV) of HDTV-TELE and HDTV-WIDE are 15.5 deg. × 8.7 deg. and 50.1 deg. × 29.5 deg., respectively, and the angles of incidence are 18.5 deg. and 157.5 deg from +X axis of the spacecraft to the nadir, respectively. For the detail of HDTV specification, see [1][3].

Coverage: As of the end of November in 2008, HDTV has acquired 128 movies and 141 still images. The number of the images obtained is 229858 in total and the data amounts to 1.37 TB after decompression .

Figure 1 shows the coverage of HDTV observation. The rectangles in yellow show the footprints of movies by HDTV-WIDE and those in magenta color indicate the area observed by HDTV-TELE. The rectangles in cyan represent the areas observed by the still images at the time interval of 16sec, that aimed to increase the coverage. The other still images are mainly obtained for the calibration purpose[4].

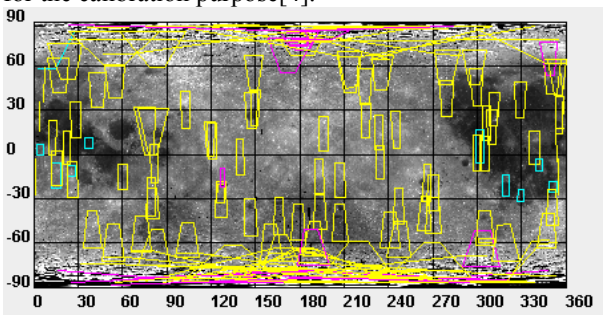

Figure 1. The coverage of HDTV observation. The mosaic image by Clementine[3] is used as the base map.

Imaging of the full Earth : HDTV's primary objective is to obtain the moving images of the "full" Earth rising from the lunar horizon and setting to the lunar horizon. We have succeeded in the acquisition of these images on April 5 th and September 30 th in 2008. Figure 2 shows a snapshot extracted from the moving images of the full Earth rise from the lunar South Pole obtained by HDTV-TELE on April 5th, 2008. These moving images are taken at the smallest frame rate among the four frame rates of 30fps, 15fps, 7.5dps, and 3.75fps .

Figure 2. A snapshot of the Earth-rise from the lunar South Pole obtained by HDTV-TELE on Apr. 5th, 2008. The original image size is 1920 x 1080 pixels.

Imaging with attitude fixed to the inertial space: The +Z axis of the KAGUYA is nominally kept directed toward the center of mass of the moon, and thus HDTV constantly captures the lunar horizon in the center of FOV. On July 4th and December 11th – 12th, 2008, the attitude of spacecraft was kept fixed to the inertial space for the calibration purpose of CPS and GRS. Since KAGUYA is the polar orbiting spacecraft, HDTV can observe the lunar surface at the various viewing direction relative to the vertical direction in this condition.

HDTV acquired 10 moving images during this period and succeeded in obtaining the images in which lunar horizon transverses the FOV of HDTV (Figure 3). Furthermore the close-up view of the lunar surface was acquired when the viewing direction approached the vertical direction. Figure 4 is a snapshot from the moving images obtained by HDTV-TELE when the angle between the direction of the center of the FOV and the vertical direction was about 7°. The resolution of the image is about 14 m, which is several times better than the nominal resolution of about 45m/pixel for HDTV-TELE and about 85m /pixel for HDTV-WIDE.

Figure 3. A snapshot around the Grimaldi (in the lower left, the center is located at (5.5° S, -68.3° E), D= 172km) and the Oceanus Procerallum, obtained by HDTV-WIDE at 2008/12/12 13:56:21(UT).

Figure 4. A snapshot around the central peak of Pythagoras (the center is located at (63.5°N, -63°E), D=142km) , obtained by HDTV-TELE at 2008/12/12 08:36:00 (UT).

Data analysis - DEM creation by Stereo matching- : If we consider HDTV as collection of 1-D sensors, a pair of images created by sampling of two specific lines from each frame of the movie, can be used to obtain the digital elevation model (DEM) via stereo matching.

The basic idea of the DEM creation by HDTV movie is shown in Figure 5. For simplicity and the preliminary experiments, we ignore the effect of spherical shape of the lunar surface and assume the images are taken under the epipolar geometry condition. Under this assumption, the height of the specific point, *H,* is obtained by the following equations,

$$H = B\frac{\sin\alpha\cdot\sin\beta}{\sin(\alpha-\beta)},\quad B = V(t_2 - t_1),\qquad (1)$$

where B is the baseline length, V is the velocity of the spacecraft, α and β are the viewing angle for the two specific lines on CCD, t_1 and t_2 are the time when the target point are caught by these two lines of CCD.

For the experiment, a pair of images were created by extracting the 20 th and 270 th lines, which corresponds to α=36.7° and β=29.9°, respectively. The original resolution for time is 0.27sec at 3.75 fps (8x recording mode), however since we obtained the parallax for stereo matching at the resolution of 0.1pixel via spline interpolation, the resolution of $\Delta t = t_2 - t_1$ ranges from 0.027sec and 0.27 sec. Substituting this values and V=1.6km into equation (1) , we obtain the height resolution ΔH ranging from 107m to 1.07km .

Figure 6 represents the perspective shaded relief image of thus obtained preliminary DEM from the movies of the Aristarchus plateau on February 1st, 2008 (UT)). The depressions in the Vallis Shoroteri in the lower left and the area around the sinus rill in the right, and three hill-like structures are well recognized. The result indicate the HDTV images are usable to obtain DEM, however, the unrealistic assumption should be removed and the accuracy of the absolute values of the height of each point should be checked referring to the LALT data or TC-DEM in the future study.

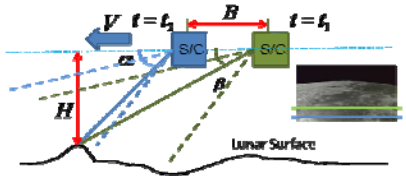

Figure 5 The schematic view of stereo matching by HDTV moving images.

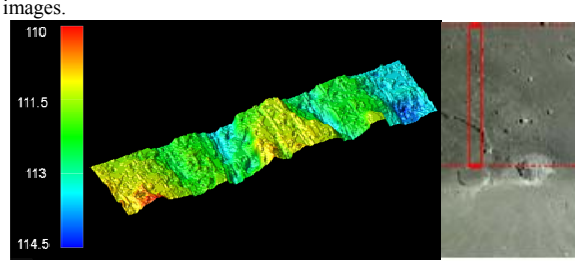

Figure 6 The perspective shaded relief image of the DEM. created for the red rectangle areas in the image in the right. The color bar indicates the value of H in km.

Conclusion: After 16 month operation in space, HDTV is kept in a good condition and 1.37GB data including the full Earth was successfully obtained. The obtained moving images are also applicable to creation of DTM at the height resolution ranging from 100m to 1km.

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