INITIAL RESULTS OF IMAGING OF LUNAR FEATURES BY HIGH-DEFINITION TELEVSION (HDTV) ON BOARD SELENE (KAGUYA).

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Introduction: High-Definition Television (HDTV) on board SELENE (KAGUYA) [1] is the world's first high-definition video imaging system developed for autonomous operation on the spacecraft, which is designed to capture video of the Earth rising from the lunar pole. Up to 1 January 2008, HDTV has succeeded in obtaining about fifty video sequences including the Earth-rise, the Earth-set, and prominent features on the Moon. The HDTV's original objectives are public outreach and education, however, since HDTV takes the images at a short time interval and in the oblique view, some potential applications for lunar science such as photometric studies are considered.

This paper presents the specification of the HDTV, the data obtained up to this point, and the preliminary report on the potential application of HDTV data for lunar science.

HDTV Specification: HDTV consists of two cameras, HDTV-TELE (telescope camera) and HDTV-WIDE (wide-angle camera), and a common data processing unit. HDTV weighs 16.5 kg and consumes the maximum power of 50 W. The field of view 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.

Each camera generates three color images of 1920 pixels x 1080 pixels in size with the A/D resolution of 12 bit. The image are separated through a dichroic prism into three bands and deposited on separate CCDs. In the standard (1x) mode, the video image of 1-minute long is obtained at the frame rate of 1/30 sec and recorded on the EEPROM of 1GB after HDCAM-type compression. The interval-record modes (2x, 4x and 8x) are also available, in which 2-minute, 4-minute and 8-miniute long videos are obtained at the frame rate of 2/30sec, 4/30sec, and 8/30sec, respectively.

HDTV-WIDE with the interval mode 8x is generally used to observe features on the Moon. The resulting best pixel resolution at the altitude of 100 km is about 130 m in the across track direction and 460 m in the along track direction, which resolution is comparable with Clementine UVVIS spatial resolution [2], and inferior to that of AMIE (40m/pixel at 400 km periling height) [2] of SMART-1.

The exposure time of HDTV is automatically set for each frame by referring the intensity histogram of the frame. Since the value of the precise exposure time of each frame is not recorded in the telemetry, we must use the super-imposed mode, in which the figures of the exposure time are directly recorded in the corner of the image.

Operation: After the launch of SELENE, HDTV captured the first video image of the Earth going away from SELENE at the distance of 110,000 km from the Earth on 29 September 2007. After the spacecraft went into the lunar polar orbit at the altitude of about 100 km, the initial check out of HDTV was conducted on 28 October 2007 and the intensive observation by HDTV had started and continued until the middle of December 2007, when the nominal operation of the other scientific instruments started. Currently, the frequency of HDTV imaging is decreased down to once or twice per month, however, the observation still continues and the instrument is kept in a good condition.

Obtained Data: As of 1 January 2008, we have obtained three video images of the Earth-rise, two video images of Earth-set, and 40 video images captured when the spacecraft was flying over the prominent lunar features such as Copernicus, Orientale Basin and Aristarchus. Table 1 summarizes targets observed up to this point.

Fig. 1 shows an example of the snapshot extracted from HDTV-WIDE video. The prominent crater in the center is Jackson (71km in diameter) which lies on the far side of the Moon, at 22.4 deg N, -163.1 deg E. Fig. 2 presents the close-up view of the center and the inside of the east-side wall of Jackson. The oblique view of HDTV enables the detailed observation of complex form of the central peak and the crater wall, such as the terracing and grooves inside it.

Table 1 Observed targets on the Moon.

Mare: Mare Australe, Mare Orientale, Mare Moskow
Craters: Copernicus, Aristarchus and Rimae Aristarchus, Tsiolkovskiy, King, Poynting, Hertzsprung, Jackson, Oppenheimer, Zeeman, Mendeleev, Leibnitz, Lyot, Posidonius, Ohm,
Polar region: Shakeleton, Schrodinger and Vallis Planck, Drygalski, Plaskett
The boundary between Mare and highland: The east border of Oceanus Procellarum, Mare Imbrium to Sinus Iridum and Montes Jura.
SPA related feature : Mare Ingenii, Apollo

Fig. 1 A snapshot of Jackson crater (71 km in diameter) extracted from video taken by HDTV-WIDE.

Fig 2. The close-up view of the wall and the central peak of crater Jackson .

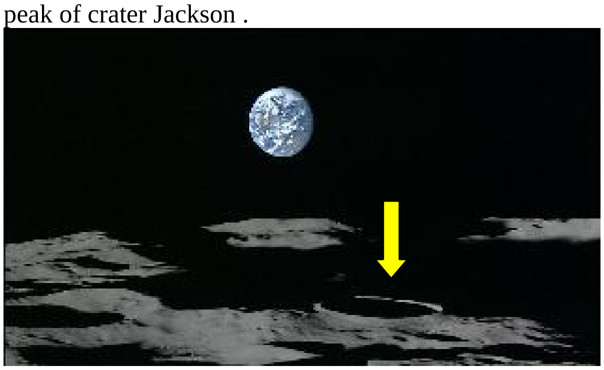

Fig. 3 A snapshot extracted from the video of the Earth-set at the lunar South Pole by HDTV-TELE. The crater indicated by an yellow arrow is Shackelton.

Fig. 3 shows a snapshot of the Earth-rise at the South Pole. The crater indicated by an yellow allow is Shakeleton (19km in diameter, located at 89.9° S, 0.0° E), which is considered to have the permanent shadow inside. Fig. 3 indicates that the oblique view of HDTV is useful to observe the wall in the permanent shadow, and thus HDTV data will be utilized for studies of crater walls in the polar region, to search for the relatively bright icy patches inside the permanent shadow.

Furthermore, HDTV video can be converted into the long strip swath image by extracting specific lines from each frame. Fig. 4 shows a part of a long strip image created by extracting the 1060th line from each frame. The prominent crater in the left is Lavoisier which lies on the boundary between highland and Oceanus Procellarum. By utilizing hundreds of frames sequentially captured at the time interval of 8/30sec, a large number of samples for a specific point with the different observational condition (i.e., the incident angle, the phase angle, and the emission angle) are collected without the effort of spatial registration among bands. Such data set will be useful to investigate the photometric properties of lunar surface and also to study features with the anomalous photometric property such as features found on the fractured floor of crater Lavoisier reported in AMIE observation [3]. In addition, a pair of swath images created by extracting different lines is also utilized to create Digital Elevation Model.

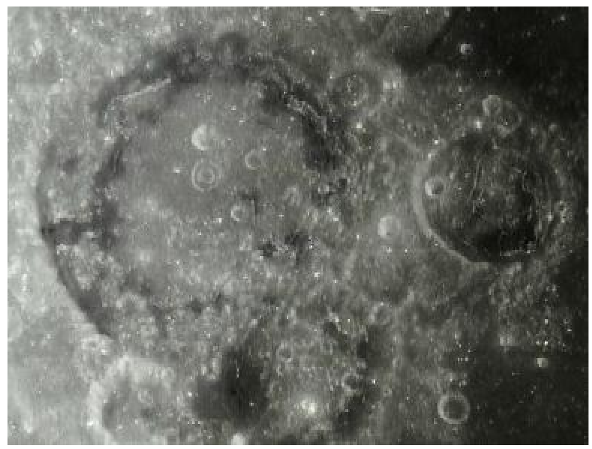

Fig. 4 The color image of crater Lavoisier produced by sampling the 1060th line of each frame and by scaling. The contrast of the images is enhanced.

Conclusion: After two month operation in the lunar orbit, HDTV successfully captured about fifty sequences of video images. Considering the characteristics of HDTV data such as the various observational conditions for a specific point due to the successive data acquisition, the oblique view, and the precise spatial registration among the color bands, HDTV data is expected to be utilized for scientific objectives such as the photometric studies and the detailed observation of crater walls and Mountains to supplement other instruments' result such as AMIE of SMART-1, TC and MI of SELENE, as well as public outreach..

Acknowledgement: The authors are grateful to Y. Iijima, H. Otake, H. Maejima (JAXA) for their support.

References:

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