TARGET SIGNATURE ANALYSIS VIA HUMANOID MACHINE VISION SYSTEM

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Abstract – **Humanoid Machine Vision System (HMVS) based on PAL-optic is the newest version of Centric Minded Imaging (CMI). It is characterized by a 360° panoramic peripheral and a 10°-40° foveal (centric) view. In this project author report on how the foveal view can be used for remote target signature analysis when the HMVS is mounted on an Automated Guided Vehicle (AGV), such as a planetary rover. As an example, two-color signature analysis and polarization characterization will be mentioned.**
Key words: Centric Minded Imaging, Panoramic Annular Lens, Automated Guided Vehicle (AGV), spectral analysis, target signature.

I. INTRODUCTION

The Panoramic Annular Lens - the PAL optic (as in [6]) - is characterized by features such as:

a) A virtual image is formed inside the imaging block; it is sharp from right up against the lens surface out to infinity;

b) The visible panoramic image represents the two-dimensional skeleton of the three-dimensional environment and can be regarded as a 360° peripheral view;

c) Since the center region of the imaging block around the optical axis does not take part in creating the ring-shaped panoramic image (it serves only to transmit the image forming rays undisturbed), when an appropriately designed, well corrected imaging lens is placed in front of the PAL optic in such a way that its image plane coincides with the annular image plane inside the PAL-optic, a foveal (centric) image is created.

The consequence of the feature described in c) is that - as shown in Fig. 1. - when a mirror (7) that can be rotated and has an inclination angle β to the optical axis (2) is placed in front of this foveal lens (5), the viewing angle of which can be varies, a picture will emerge in the center (6) of the annular image (4) showing objects in a selected sector of the 360° peripheral image (9).

Thus, a somewhat similar situation has been created as one can experience in human vision. If, namely, a target in the 360° peripheral field of view is of particular interest, one can "focus in" and get more information on the morphological surface properties of this selected target, in a somewhat similar way as the human vision does. This is the reason why this system is called Humanoid Machine Vision System (HMVS). To demonstrate the possibilities inherent in HMVS when it is mounted on an AGV such as a planetary rover, author made the following experiment. The wall of a plastic cylinder was covered with the assembled panoramic Mars pictures which were the result of image components recorded by more than one video camera and that were transmitted by the Pathfinder.

Author puts the breadboard model of a planetary rover equipped with HMVS inside this cylinder in such a way that the entire panoramic scene was viewed and could be recorded in one single shot. As a result, not only a 360° panoramic view of the surrounding was displayed on the TV screen, but in the center of the annular picture, one could also observe a selected and enlarged part of the peripheral scene (a rock) thanks to the foveal vision capability of the HMVS. (Fig. 2)

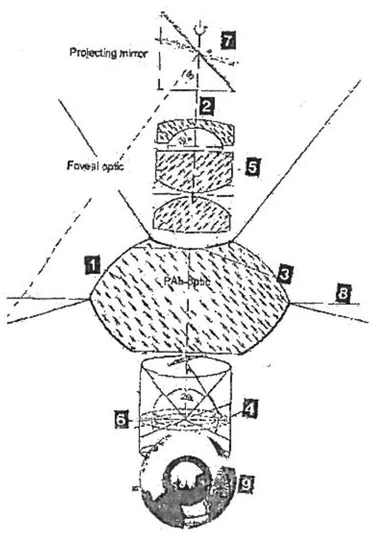

Fig. 1. Function layout of Humanoid Machine Vision System

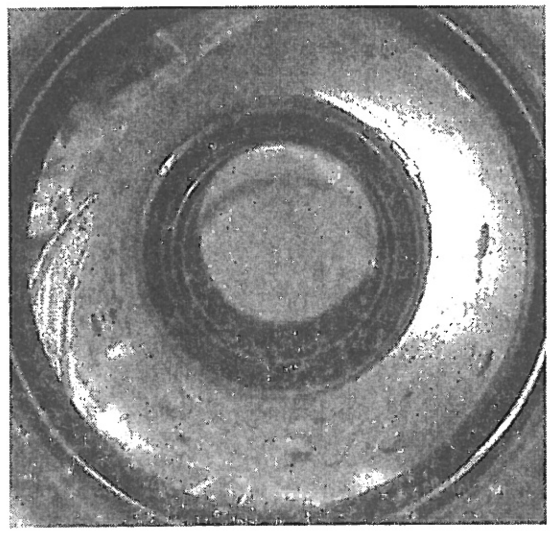

Fig. 2. HMVS image of the simulated panoramic Mars view displayed on a TV screen.

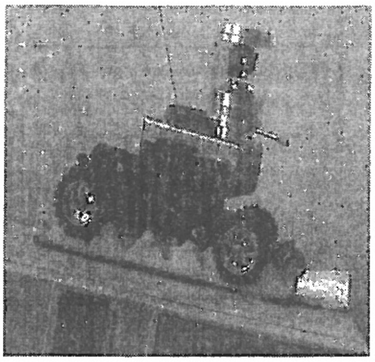

Fig. 3. Breadboard model of remote control rover equipped with a digital photographic camera with HMVS. Please observe the rotator lever of the polarizer.

II. OPTICAL REMOTE TARGET SIGNATURE ANALYSIS

A. Humanoid polarimetry

The characteristics of the HMVS, namely, that the foveal image is displayed in the same see-through-window (STW) imaging strategy as we are accustomed to in spectral analysis, and at the same time the display of the peripheral field of view uses centric minded imaging (CMI), strongly suggest that such a system may be a good candidate for target signature analysis.

Although the direct sunlight is not polarized, a substantial amount of light reflected from various surfaces may be polarized in one way or another. Polarization data acquisition uses two images conventionally acquired by two cameras or a twin-lens stereo camera where mutually perpendicular polarizers are in front of each lens as in [2]. Polarization technique was used, among others, in Venus research as in [4] and during the Space Shuttle mission as in [3].

A new technique to describe the distribution of the reflected E-vector was developed by G. Horvath in [5] and [7] to show why Kuwait oil lakes act as insect traps, taking into account that light reflected from a water surface is horizontally polarized. Thus, the polarization pattern of the reflected sun rays can be considered as target signature. This means that, unlike the sky where the E vector may be vertical at sunrise and sunset, the greatest angle the E vector can tilt from the horizontal is the angle from the vertical marked by the reflection characteristics of the surface, such as soil, ore minerals, etc as in [1].

This is the reason why proposing to use a HMVS on a planetary rover, where a linear polarizer is placed between the PAL-optic and the relay lens to detect, by rotating the polarizer by 45°, the distribution of the reflected E vector. The resulting set of data could be regarded and used as a target signature. For preliminary studies a breadboard model of a remote control AGV was designed on the top of which a digital photographic camera with HMVS was mounted (Fig. 3).

B. Two color target analysis

Starting from the recognition that two objects showing the same total radiative energy emitted in a broad band may emit different amounts of energy in another, narrower band, however, still within this broad band, we designed a HMVS which may recognize targets via so-called *two-color* target signature analysis method, which is the most advanced way to make thermal target signatures. It has already been successfully applied in industry, e.g., in testing glass, plastic, chemical and other materials. The HMVS, however, uses only one single camera, instead of two. As an example, let us assume that both objects have a radiance of 1.42 Wcm^{-2} in the 8-13 micron band, while object 1, 5.67 10^{-4} Wcm^{-2}, and object 2, 1.00 Wcm^{-2} in the 3-5 micron band.

Thus, using a ring-shaped broad band filter which is linked to that part of the HMVS that is responsible for the 360° peripheral panoramic field of view (9), and a narrower band, however, having its frequency band within that of the broad band filter and linked to the foveal image (6), one would be able to distinguish between the two objects. The data resulting from the foveal image can be regarded as a target signature. In some cases there is a possibility to combine humanoid polarimetry with two-color target analysis.

III. CONCLUSIONS

Author demonstrate that a AGV, when using centric minded imaging (CMI) represented by HMVS, opens new vistas in AGV performance, since it offers not only more flexible new navigation strategies but it is also capable to acquire target signatures from the three-dimensional environment in which the AGV is navigating, both from solid surfaces and from the components of the surrounding atmosphere, by using humanoid polarimetry and two-color target analysis.

IV. ACKNOWLEDGMENT

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V. REFERENCES

[1] A. J. Criddle and C. J. Stanley, *The quantitative data file for ore minerals,* Alden Press Ltd. ISBN 0 565 009974 Oxford, 1986

[2] W. G. Egan, P*hotometry and polarization in remote sensing*, Elsevier, New York NY, 1985

[3] W. G. Egan, "Terrestrial polarization imagery obtained from the Space Shuttle: characterization and interpretation." *Applied Optics Vol.* 30, 1991, pp 435-442

[4] J. E. Hansen and J. W. Hovenir, "Interpretation of the polarization of Venus." *J.Atmos. Sci.* 31, 1974, pp 1137-1160.

[5] Horváth, G, Zeil, "Kuwait oil lakes as insect traps." *Nature,* Vol. 379, 1996, pp 303-304.

[6] P. Greguss, "Hung. Pat. 192125; USA Pat. 4566763; Japan Pat. 1962784; German Pat. 3402847; French Pat. 2540642", 1983

[7] R. Schwind and G. Horvath, "Reflection-polarization pattern at water surfaces and correction of a common representation of the polarization pattern of the sky." *Naturwissenschaften,* Vol. 80, 1993, pp 82-83.