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# Personal Glimpse: **DIGITAL IMAGE ANALYSIS OF POSSIBLE EXTRATERRESTRIAL ARTIFACTS ON MARS**

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## 1. INTRODUCTION

In 1985 an article appeared in the Boston Globe about the discovery of a "face on Mars" by the Viking space probe ten years earlier. I had followed the mission and did not recall any such discovery. Viking's primary science goal was to search for possible signs of life on the surface, specifically, for evidence of microbes, tiny organisms, in the martian soil. The newspaper article suggested another possibility - that large artificial structures including a mile-long humanoid face might have been found on Mars. At first I though it was just a joke but soon my curiosity got the better of me. I traced the story to a small group at the University of California at Berkeley who were studying the face along with several other unusual objects that had been found in a dozen or so Viking Orbiter photographs. Shortly thereafter I obtained two tapes containing copies of the original NASA imagery.

Initially my goal was to produce high-quality digital enhancements of the imagery. As I became drawn into the investigation I soon learned that there was much more to the face on Mars. The face was extremely controversial - in fact, most planetary scientists had already decided it was an optical illusion. Although I am not a planetary scientist and therefore not an "expert," I was not convinced. I found it hard to believe that such a compellingly humanoid form could occur naturally in close proximity to other objects, some quite geometric in shape and arrangement. The certainty of the "experts" bothered me. Their conclusions were based on little, if any, detailed analysis of the data. I felt the possibility, however remote, that we had imaged extraterrestrial artifacts on Mars demanded a closer look.

## 2. BACKGROUND

Late in the 19th century the Italian astronomer Schiaparelli observed what appeared to be lines on the surface of Mars. Percival Lowell's interpretation of Schiaparelli's *canali* (channels) as artificially constructed canals, prompted considerable speculation about life on Mars. This vision was shattered in the 1960s when the early Mariner probes took the first close up pictures of Mars. These pictures showed the planet to be heavily cratered, more like the moon than the Earth. But these early probes photographed only a very small portion of the surface. In 1971 Mariner 9 imaged a larger portion of the planet changing our view of Mars once again. It found channels that appeared to be carved by water, giant volcanos almost three times as high as Mt. Everest, and a great canyon system thousands of kilometers in length. Viking 1 and 2 were launched in 1976 to follow-up on these discoveries. Its two landers found the martian soil to be highly oxidized, and to contain no organic compounds and no microbial life. The orbiters collected over 60,000 images of the surface, clouds and dust storms in the atmosphere, and Mars' two moons Phobos and Deimos.

The above discoveries of the Mariner and Viking missions are well-known. What is less known is that on a summer day in 1976 one of the Viking orbiters imaged what appeared to be a humanoid face staring up into space from the surface of Mars. NASA dismissed the face as an optical illusion and simply filed the picture away without further study. But several years later, two engineers Vincent DiPietro and Gregory Molenaar rediscovered the image of the face in the NASA archives along with a second corroborating image of it taken 35 days later [1].

Criticism of their work centered on the human tendency to find faces everywhere; in other words finding a face in isolation tells us nothing. But then in a subsequent investigation motivated by their work, other nearby objects which seemed to be related to the face were found [2]. In particular, the face appeared to be aligned with a collection of polyhedral objects to the southwest, termed the city (Fig. 1). By 1985 the investigation had continued to enlist broader interdisciplinary support in the technical and scientific community at which time I became involved.

## 3. IMAGE PROCESSING

Initially I used fairly routine image processing techniques to clean up noise and other defects in the data, to enhance subtle detail not visible in the batch-processed NASA photographs, and to magnify smaller features for analysis. Many of these early results appeared in books by Pozos [2] and Hoagland [3]. The original image of the face (frame number 35A72) was taken when the sun was about 10° above the northwestern horizon. As a result the right side is in shadow and there is little detail visible. When DiPietro and Molenaar found the second image (70A13) with the sun 17° higher in the sky, they discovered that the face exhibited a high degree of bilateral symmetry with what appeared to be a second eye socket and the extension of the mouth. In comparing carefully restored and enhanced images of the face from 35A72 and 70A13, I observed a pair of crossed lines above the eyes, fine structure in the mouth that some have referred to as teeth, and broad lateral strips across the face (Fig. 2). Geometrical regularity and fine detail have been noted in several other objects as well [4, pp. 38, 57, and 87].

The image processing results surprised me. If these were simply eroded landforms one would not expect to see such features as one examined them in greater detail. Granted, the features were near the resolution limit of the sensor, about 50 meters/pixel. Yet, they could be seen in both 35A72 and 70A13. It seemed unlikely that these structures were caused by random noise, sensor defects, or image processing artifacts.

## 4. SHAPE-FROM-SHADING

But was the face an optical illusion as NASA had stated? Since the only two high resolution images of the face were acquired at approximately the same sun angle and sensor geometry it seemed at first that one could neither prove nor disprove that statement. But then it occurred to me that if the shape of the face could be recovered somehow, one could, in principle, generate synthetic images for different sun angles and sensor geometries using computer graphics techniques. If the face was an optical illusion, a trick of light and shadow, then these images would reveal an ordinary mesa as NASA had said.

In 1986 at TASC we were exploring the use of shape-from-shading techniques for computing elevation maps from imagery. Simply stated, shape-from-shading relates changes in image brightness in the direction of the light source to the shape of the imaged object. By inverting the image formation equation

$$i(x,y) = \alpha R\left[\frac{\partial z}{\partial x}, \frac{\partial z}{\partial y}\right]$$

where R is the reflectance map which relates surface orientation to brightness and $\alpha$ is a constant of proportionality, one can estimate the relative shape of an object z(x,y) from image brightness values i(x,y).

Patrick Van Hove, a graduate student under Berthold Horn at MIT implemented an algorithm that summer at TASC that seemed to work well on recovering the shape of isolated landforms such as craters and mesas [5]. I used this algorithm to estimate the shape of the face from each of the two images 35A72 and 70A13. Since there was no "ground truth" to check the accuracy of the results, the surfaces computed from each image were used to predict the other image. By comparing the predicted image with the actual image I was reasonably sure that the recovered surface was an accurate representation of the shape of the face. Two key questions could then be addressed: Are the facial features visible in the imagery also present in the underlying surface? Do these features persist as the lighting conditions and viewpoint are changed?

Fig. 3 shows synthetic images of the face for different lighting conditions and perspectives. These results suggest that the face is not a "trick of light and shadow" as originally stated by NASA in that it retains its appearance over a wide range of viewing conditions. This is not the case for natural stone formations like New Hampshire's Old Man of the Mountain [4, pg 39]. After being initially rejected by the journal *Icarus* on the grounds that "the face is of no scientific interest", a paper describing the above methodology and results was published in *Applied Optics* in May 1988 [6].

## 5. FRACTAL ANALYSIS

Following the publication of the above paper the noted planetary scientist, Carl Sagan, sent me a copy of an article he had written for *Parade Magazine* several years earlier. In it he points out the tendency of the human mind to find faces in practically anything, from clouds to tortilla chips, suggesting that the "face on Mars" is no different than "the man in the moon." I began to wonder whether there was a more objective way to evaluate this imagery. Was possible to determine if the structure of the face and other objects was quantitatively different from the surrounding terrain and nearby landforms?

At about that time we were becoming interested in the use of fractals for analyzing images. In short, fractals are objects that are self-similar in structure - in some sense, a portion of a fractal resembles the whole. Fractals had been previously used with great success to generate realistic terrain backgrounds for computer animations (recall the Genesis sequence from the movie *Star Trek II* ). Locally, fractals are good models for terrain because the structure of terrain exhibits a high degree of self-similarity over spatial scales less than about 1 km. It has been observed that the structure of man-made objects, on the other hand, tends to dominate at particular scales.

As with shape-from-shading, the timing was fortuitous. At TASC we had recently developed an image processing algorithm for detecting man-made objects such as military vehicles in aerial photographs using a fractal modelling approach [7]. The basic idea is to measure the deviation from fractal behavior over a range of scales using a least squares model

$$\varepsilon = \sum_{r} \left[\log M(r) - (a \log r + b)\right]^2$$

where M(r) is some metric property of the image such as its power spectral density or surface area, r is the scale of measurement, a and b are constants that minimize the residual error ε. For fractals $M(r) \sim r^{f(D)}$ where f(D) is some function of the fractal dimension D. Since fractals scale according to a power law, the signature of a fractal is a straight line in log r vs. log M(r) space where a is the slope of the line and is related to the fractal dimension. As a result, ε tends to be small over those portions of the image containing natural terrain features and large where there are man-made structures. Fig 4a shows the results of applying this algorithm to a Landsat image containing a small small town near the center of the picture.

When the above algorithm was applied to the Viking imagery the face was found to be the least fractal object in 35A72 (Fig. 4b) and among the least fractal object in 70A13! (Fig. 4c). The analysis was carried out over a 21x21 window (corresponding to a range of scales from 50 meters to about 1 km). Further analysis revealed the face and several objects within the city to be the least fractal areas in the four available Viking Orbiter frames 35A70-35A73 (total area ~ 15,000 sq. km). After being rejected by the journal *Nature* on grounds similar to those cited by *Icarus*, these results were eventually published in the *Journal of the British Interplanetary Society* early in 1990 [8].

## 6. DISCUSSION

These results appear to suggest that the face along with several other objects in the city are quantitatively different from the surrounding landforms. The face is not an optical illusion. It is also the least natural object encountered in the imagery examined thus far. So, what is my conclusion?

Mainstream planetary scientists argue that these objects cannot be artificial because no life, let alone a technological civilization capable of creating such objects could possibly have developed on Mars in time according to current theories. Another possibility, that Mars may have been visited by an intelligence from outside our solar system, is usually dismissed as pure speculation. As an aside many of these same individuals support NASA's $10 million search for extraterrestrial intelligence (SETI) using radiotelescopes. If it is legitimate to listen in the microwave portion of the electromagnetic spectrum for extraterrestrial radio signals, why not use our planetary probes to look for their artifacts or signs of altered terrain on planetary surfaces? Perhaps the answer is more political than scientific.

At the other extreme those who already believe in extraterrestrials embrace these results as proof. Some see these objects as monuments, possibly even conveying some kind of message to us. It seems to me that the key question that must be addressed is simply: Are these objects artificial, or are they natural?

Last September our latest planetary probe, the Mars Observer [9], was launched towards the red planet. If all goes well, it will enter orbit later this year and begin to image the martian surface at resolutions approaching 1 meter/pixel [10]. I think it is clear that the work summarized in this paper in no way proves that these objects are artificial. It is my hope, however, that it does legitimize the hypothesis that certain objects on the martian surface may not be natural and deserve to be re-imaged. The Mars Observer mission provides an unprecedented opportunity to follow-up on these potential discoveries of Viking. For the first time it affords us the unique opportunity to either confirm or deny, by purely technical means, the existence of extraterrestrial life, not just in the universe but practically "next door" to us on Mars.

## REFERENCES


[1] DiPietro, V. and Molenaar, G. (1982), Unusual Martian Surface Features, Mars Research, Glenn Dale, MD.

[2] Pozos, R. (1987), The Face on Mars: Evidence for a Lost Civilization?, Chicago Review Press.

[3] Hoagland, R. (1987), The Monuments of Mars: A City on the Edge of Forever, North Atlantic Books, Berkeley CA.

[4] Carlotto, M.J. (1992), The Martian Enigmas: A Closer Look, North Atlantic Books, Berkeley CA.

[5] Van Hove, P and Carlotto, M.J. (1986) "An iterative multi-resolution shape from shading algorithm and its application in planetary mapping," International Geoscience and Remote Sensing Symposium, Zurich, Switzerland.

[6] Carlotto, M.J. (1988), "Digital imagery analysis of unusual martian surface features," Applied Optics, Vol. 27, pp 1926-1933.

[7] Stein, M.C. (1987), "Fractal image models and object detection," Proceedings SPIE, Vol. 845, pp 293-300.

[8] Carlotto, M.J. and Stein, M.C (1990), "A method for searching for artificial objects on planetary surfaces," Journal of the British Interplanetary Society, Vol. 43, pp 209-216.

[9] Komro, F.G. and Hujber, F.N. (1991), "Mars Observer instrument complement," Journal of Spacecraft and Rockets, Vol. 28, pp 501-506.

[10] Malin, M.C., Danielson, G.E., Ravine, M.A., and Soulanille, T.A. (1991), "Design and development of the Mars Observer Camera," International Journal of Imaging Systems and Technology, Vol. 3, pp 76-91.

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MARK J. CARLOTTO was born in New Haven, Connecticut in 1954. He received his B.S., M.S., and Ph.D. degrees from Carnegie-Mellon University in 1977, 1979, and 1981, respectively. He has been employed by TASC in Reading Massachusetts since 1981. From 1981 to 1983 he was an Assistant Adjunct Professor at Boston University where he taught courses in computer architecture and image processing. At TASC he is currently a Division Staff Analyst and is involved in a variety of projects related to multispectral image processing, content-based image retrieval, and information visualization. He has written one book and almost fifty technical papers in the areas of digital image processing, pattern recognition, and optical computing. He is a senior member of the IEEE.

Other talks had to do with SETA, the search for extraterrestrial artifacts, which will be one subject of future research by the German research network. Hakan Kayal from the University of WÃ¼rzburg outlined todayâ€™s technical state of the art in detecting and identifying objects in space, whether natural phenomena such as meteorites and sprites, or presumed extraterrestrial probes.Â  Other experts in the research network are addressing questions of possible cultural exchange and communication between a putative extraterrestrial civilization and humans. Advanced alien civilizations might use probes to engage in interstellar communication or observe other planets such as Earth. hydrogen water hydrogen peroxide hydrogen sulfide hydrogen cyanide helium Human Exploration of Mars Science Analysis Group high-gain antenna heavy-lift launch vehicle human lunar return hydroxy-terminated polybutadiene. initial mass in low-Earth orbit specific impulse in-situ resource utilization International Space Station.Â  A strong motivating factor for the exploration of Mars is the search for extraterrestrial life. However, this search could be permanently compromised if explorers carry Earth life and inadvertently contaminate the martian environment. Additionally, we must guard against the remote possibilities that samples returned from Mars could contain living organisms that might reproduce on Earth and damage some aspect of our biosphere.