Natural-like technosignatures and artificial intelligence. Cognitive bias implications.

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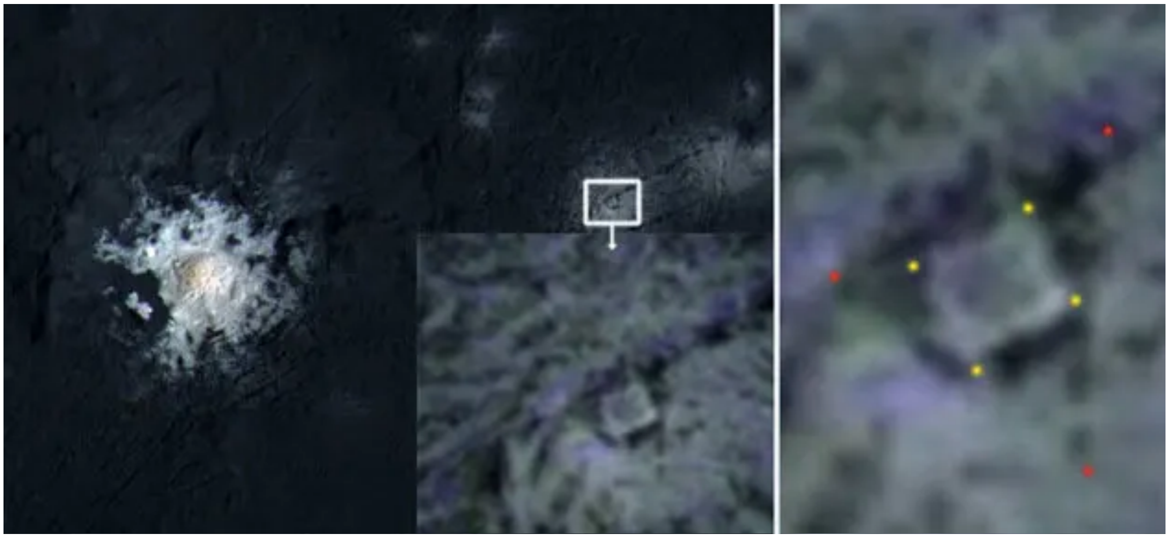
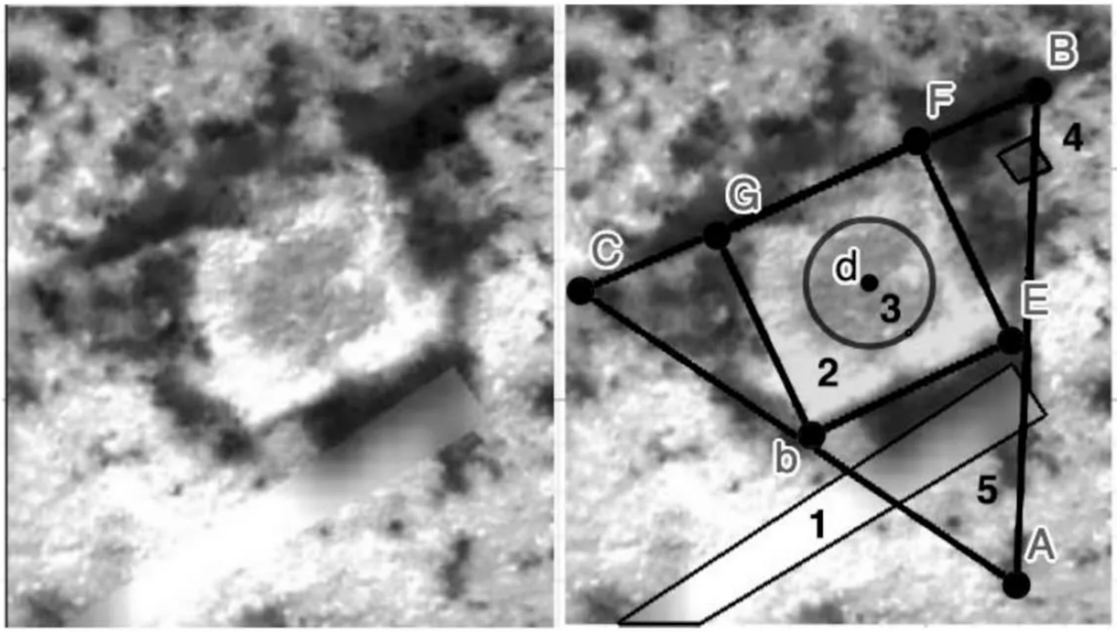
PRESENTED AT:

CERES

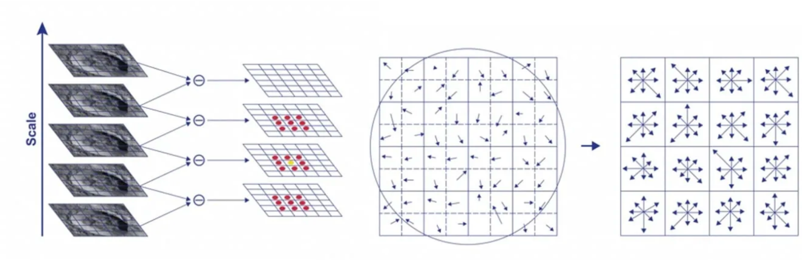


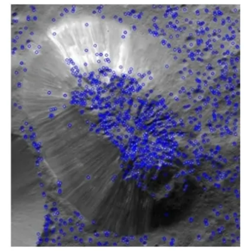
In our previous research published in Acta Astronautica (De la Torre, G.G. Does Artificial Intelligence dream of non terrestrial technosignatures? Acta Astronautica, 2020) we showed how a supervised machine learning model (Convolutional Neural Network or CNN) performed against humans in a perception task focused on an specific and strange formation at Vinalia Faculae, Occator Crater in Ceres. Suprisingly this CNN model detected both square and triangle formations in this specific region of the famous bright spots at Occator. The objective was to see if Artificial Intelligence (AI) systems could be free from cognitive bias when comapred to humans. The CNN AI model took us to a very difficult situation where the impossible was the result. This situation creates a cognitive dissonance that leave us at one difficult position. Either the AI is detecting something we cannot accept or AI is suffering from the same cognitive bias than humans have. This opens an intersting dilema for future uses of this technology in the technosignatures search.

Recognition	5A	5B	1	2	3	4
yes	11.00	63.20	85.30	47.20	66.90	36.20
no	89.00	36.80	14.70	52.80	33.10	63.80

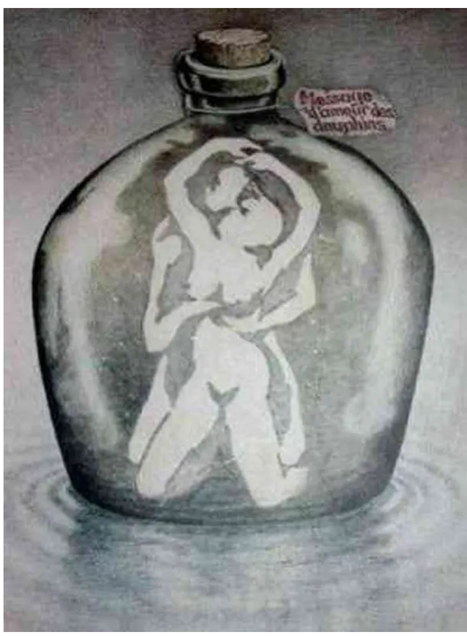


COMPUTER VISION AND COGNITIVE BIAS



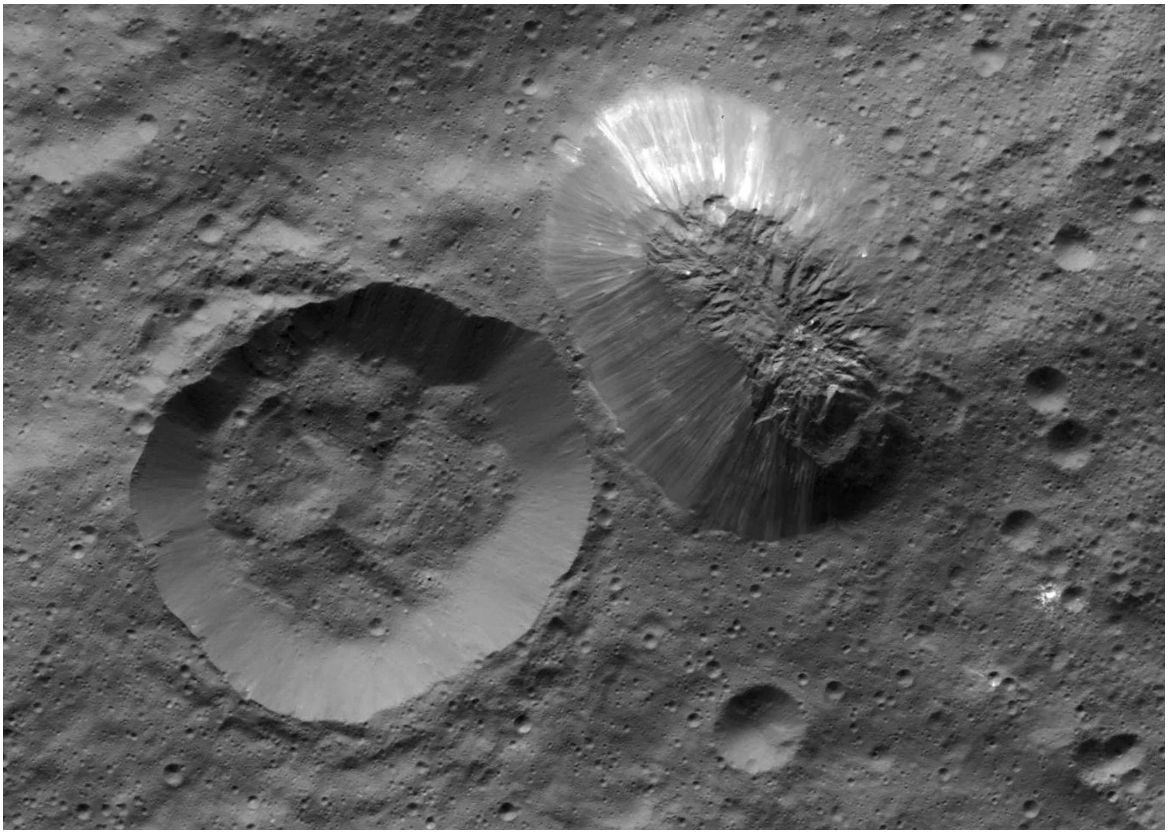


Computer vision is a form of artificial intelligence that trains computers to interpret reality; it has been an active area of research for decades. Common goals include the detection, recognition, and identification of objects or scenes within images or videos. There are several types of feature descriptors used in computer vision. Some of the most popular types of features include corner, blob, and feature descriptors including the techniques Scale-Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), Oriented FAST and rotated BRIEF (ORB), and the Canny Edge detector (Canny).



Visual perception allows us to interpret our environment. This process is based on the transduction process of transforming light from the visible spectrum to nervous impulses and subsequent perceptions. It is well-known that what we ‘see’ does not necessarily correspond to the objective reality. This is due to perception being a complex process where top-down and bottom-up mechanisms take place, with experience, expectations, and culture participating as main actors. Visual experience often serves as a basic example of conscious experience. Perceptual and other cognitive functions are determined by our physiology and neural circuits, limiting our comprehension of reality and constructing one as we give effort, attention and intentions to specific stimuli in our environment. These phenomena are frequent sources of perceptual and attention errors, which usually pass inadvertently in front of our eyes. For example, in cognitive psychology, we know that when people perform a selective looking or searching task by devoting attention to some aspects shown on a screen while ignoring others, they often fail to notice unexpected information that may happen in that same display. This trend is called ‘satisfaction of search’, meaning that people are less likely to search for additional targets once they have found their original target. Also, development and experience has an impact and that is the reason why in this image (left) children only see dolphins and you probably saw two lovers.

AHUNA MONS AND CRATER B



Ceres is the closest dwarf planet to the Sun. The surface of Ceres contains water ice and various hydrated minerals. There is an open debate in the scientific community about the presence of cryovolcanism. NASA's Dawn mission observed Ahuna Mons, a 4 km high landform on Ceres interpreted to be a cryovolcanic dome (Ruesch et al., 2016). Cryovolcanism is a form of volcanism involving water or other volatiles instead of silicate magmas (Kargel, 1991). Cryovolcanic domes have been detected on other planets and moons such as Titan, Europa, and Pluto. According to Ruesch and collaborators (2016) "the ~17-km-wide and 4-km-high Ahuna Mons has a distinct size, shape, and morphology. Its summit topography is concave downward, and its flanks are at the angle of repose. The morphology is characterised by (i) troughs, ridges, and hummocky areas at the summit, indicating multiple phases of activity, such as extensional fracturing, and (ii) downslope lineations on the flanks, indicating rockfalls and accumulation of slope debris". However, this debris accumulation is not so clearly perceived in the space between Ahuna Mons and Crater B (NW side), ending in a very sharp defined contour which extends beyond to the south and north sides of it. It is believed that some form of material extruded at high viscosity is needed to explain the dome relaxation morphology. However, opinions contrary to cryovolcanic hypotheses exist, stating that those other cryovolcanic domes exist on moons around giant planets like Jupiter, receiving heat from tidal friction that is not possible on Ceres. Also, radiogenic material could not explain that heat, given the age of the solar system and the fact that no flow features or other morphological indicators for cryovolcanism have ever been found on the dome. In this project, we used Open Cv2 (Open-Source Computer Vision Library) to extract features from both the Ahuna Mons-Crater B and Ahuna Mons-Equator Crater pair of images through SIFT, SURF, ORB, and Canny Edge feature detection/extraction techniques and matched them across to stitch the images together. We also performed 3D object analysis derived from imaging data of both structures and tested how both objects fit in tridimensional space using specific 3D rendering software.

RESULTS

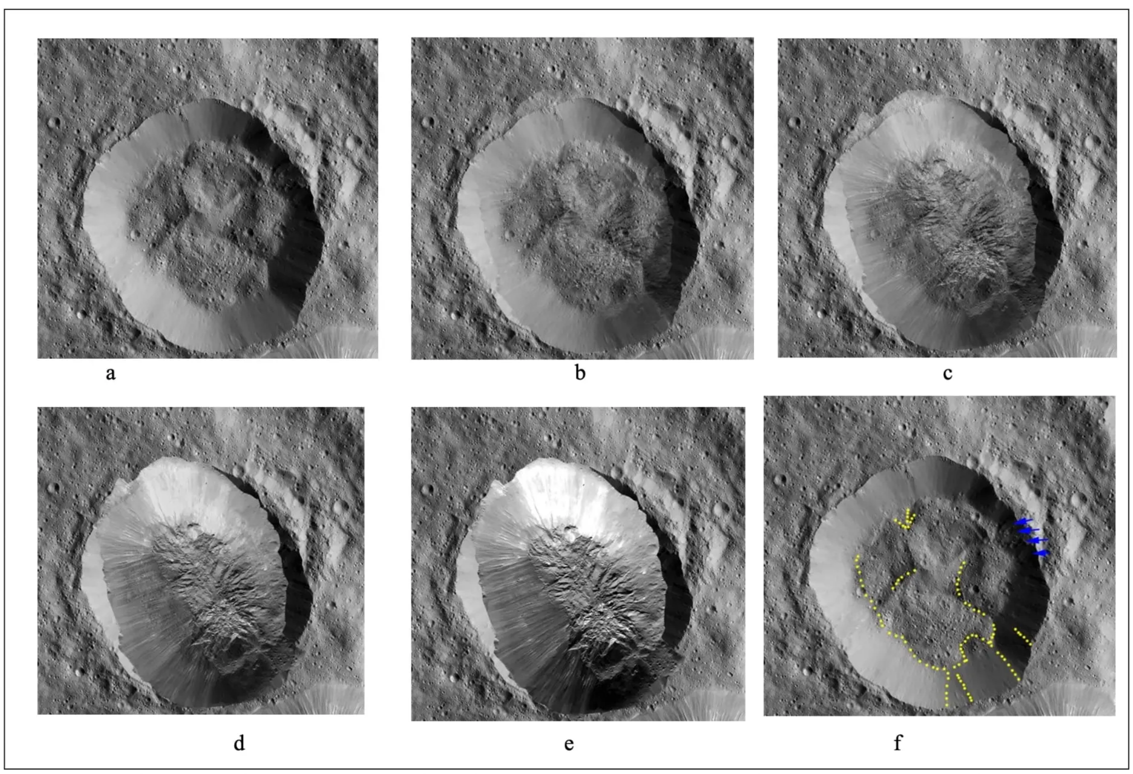
Method	Total Matches	Best Filtered Matches	Match Ratio	Execution Runtime (Seconds)
SURF	1781	3	0.1684	1.462
SIFT	1500	0	0.0000	0.699
ORB	200	0	0.0000	0.059
Canny Edge	1018	2	0.1964	0.842

Quantitative comparison and computational costs of the different feature detector descriptors for baseline analysis (Ahuna Mons vs Equator Crater).

Method	Total matches	Best filtered matches	Match ratio	Execution runtime (seconds)
SURF	1526	87	5.701	0.873
SIFT	1500	56	3.733	0.613
ORB	4682	52	1.111	0.739
Canny Edge	1223	17	1.390	0.473

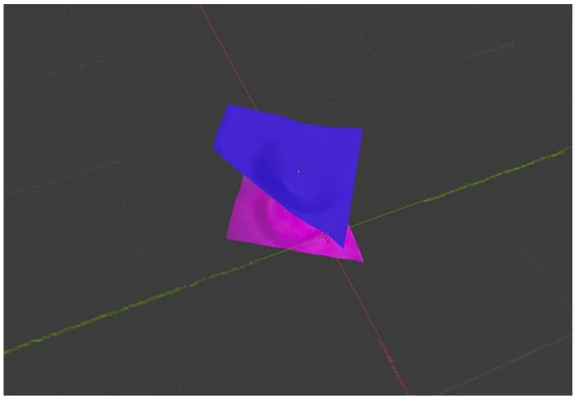
Quantitative comparison and computational costs of the different feature detector descriptors (Ahuna Mons vs Crater B).

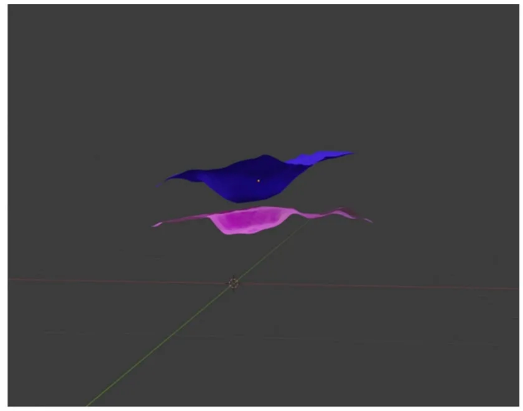
All four techniques resulted in effectively finding matching features for Ahuna Mons and Crater B but not for Ahuna Mons and Equator Crater. Among them, the Canny Edge feature stood out as the best in terms of performance as well as the fastest execution runtime in the experimental condition. The other techniques, although they offered good results, were noisier with irregular stitching results. Also overlapping Ahuna Mons and Crater B gave intersting results:

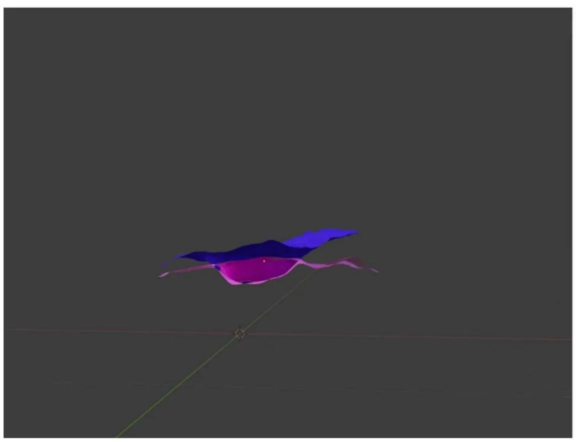


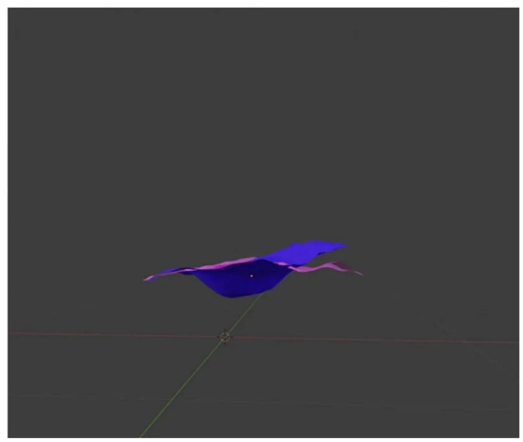
Analysis of gradual overlapping of Ahuna Mons and Crater B (Crater B 100% (a), 25% superimposed Ahuna Mons (b), 50% (c), 75% (d) and 100% (e). (f) Image of Crater B shows some examples of the overlapping features between Ahuna Mons and Crater B (yellow dots) with Ahuna Mons ("e "and "a" images), especially the south region with particular squared formation. Blue arrows show how this side is also in both cases the more cratered one. Original images credit: **NASA/JPL-Caltech/UCLA/MPS/DLR/IDA (130-140 m/px)**

Finally, in order to qualitatively compare 3d objects of both structures, Ahuna Mons and Crater B, we developed 3D model objects of both using digital elevation models (DEM) of Ceres obtained from Dawn mission (coordinate reference system (CRS): Equirectangular Ceres, Environmental Systems Research Institute (ESRI): 104972), cutting later the areas of interest (Ahuna Mons and Crater B) using Geospatial Data Abstraction Library (GDAL) > clip raster by extent). Then we imported the orthophotos or geometrically corrected images of both structures, obtained as well from Dawn mission data, into Open-source Geographic Information System (QGIS) and later into Blender Open-source 3D suite where they both were rendered. Interestingly we could see how inverted Ahuna Mons 3D model (blue) fits very well into Crater B (pink):









IMPLICATIONS FOR TECHNOSIGNATURES SEARCH

1) Cognitive styles may produce cognitive bias in any workplace and this situation may act as a filter, producing blindness to non-attended peripheral data, as it has been shown before in cognitive psychology (Neisser, 1979; Simons and Chabris, 1999; Simons, 2010, De la Torre, 2018).

2) AI systems may reach a level of processing information and subsequent outcome for what we are not ready to understand. This may happen because these AI synthetic systems do not have our biological, cultural, and psychological bias and limitations.

3) In the future, we have to be prepared for the possibility of a new form of technosignature, a natural-like object/phenomena where natural patterns are artificially or intelligently designed to be mostly indistinguishable from Nature.

4) We may need AI eyes and multidisciplinary teams to perceive and identify them, whether they are star-like megastructures (Dyson spheres) (Dyson, 1960) or mountains.

ABSTRACT

Natural-like technosignatures candidates may represent a detection problem for both artificial systems and humans. We tested traditional computer vision models with natural formations with special characteristics, Ahuna Mons region in Ceres in this particular case. We looked if these artificial models may represent a trustful aid to human detection and identification of potential technosignatures in planetary surfaces. Ahuna Mons is a 4km particular geologic feature on the surface of Ceres of possibly cryovolcanic origin. The special characteristics of Ahuna Mons are also interesting in regard of its surrounding area, especially for the big crater besides. This crater possesses similarities with Ahuna Mons including diameter, age, morphology, etc. Under the cognitive psychology perspective and using current computer vision models we analyzed these two features on Ceres for comparison and pattern recognition similarities. Several algorithms were employed avoiding human cognitive bias. 3D analysis from images of both features characteristics are discussed. Results showed positive results for these algorithms about similarities of both features. Discussion is provided about implications of this pilot computer vision techniques experiment for Ahuna Mons and the potential cognitive bias problem of both human and Artificial Intelligence models and the risks for the search of technosignatures.

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