CITIZEN SCIENCE: Introduction

Dr Jessica Wardlaw

'3D generation and multi-sensor data fusion and its subsequent 3D visualisation for planetary science applications.'

UCL Mullard Space Science Laboratory,

7th-9th June 2016.

Introduction to Citizen Science.

- What do we mean by 'Citizen Science'?
- Its current incarnation: Examples of projects from astronomy and planetary science
- Human aspects of Citizen Science projects
- What iMars aims to achieve with Citizen Science

300 years of Citizen Science

“Scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions” (OED, 2014)

“Public participation in scientific research.” (Hand, 2010)

300 years of Citizen Science

PHILOSOPHICAL TRANSACTIONS:

III. *Obſervations of the late* Total Eclipſe *of the* Sun *on the* 22d *of* April *laſt paſt, made before the* Royal Society *at their Houſe in* Crane-Court *in* Fleet-ſtreet, London. *By Dr.* Edmund Halley, *Reg. Soc. Secr. With an Account of what has been communicated from abroad concerning the ſame.*

THough it be certain from the Principles of Aſtronomy, that there happens neceſſarily a Central Eclipſe of the Sun in ſome part or other of the Terraqueous Globe, about Twenty Eight times in each Period of Eighteen Years; and that of theſe no leſs than Eight do paſs over the Parallel of *London*, Three of which Eight are Total with continuance: yet, from the great Variety of the Elements whereof the *Calculus* of Eclipſes conſiſts, it has ſo happened that ſince the 20*th* of *March*, *Anno Chriſti* 1140, I cannot find that there has been ſuch a thing as a Total Eclipſe of the Sun ſeen at *London*, though in the mean time the Shade of the Moon has often paſt over other Parts of *Great Britain*.

The Novelty of the thing being likely to excite a general Curioſity, and having found, by comparing what had been formerly obſerved of Solar Eclipſes, that the whole Shadow would fall upon *England*, I thought it a very proper Opportunity to get the Dimenſions of the Shade aſcertained by Obſervation; and accordingly I cauſed a ſmall Map of *England*, deſcribing the Track and Bounds thereof, to be diſperſed all over the Kingdom, with a Requeſt to the Curious to obſerve what they could

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300 years of Citizen Science

PHILOSOPHICAL TRANSACTIONS:

Place	Obſerver	Beginn. h. ′ ″	Immerſ. h. ′ ″	Emerſ. h. ′ ″	Tot. ′	End. h. ′ ″
Barton	M. *Bridges*				3.53	
Bell-bar	M. *Jones*	8. 6.25	9. 9.45	9.13.27	3.42	
Broadway } *Carmarth.*			8.47.00	8.49.30	2.30	
Cambridge	M. *Cotes*			9.14.37		10.21.57
Canterbury	M. *Gray*	8.10.00				10.24.30
Cheſter	M. *Ward*	7.57.40				10. 6.35
Crew	M. *Wright.*		9. 2. 8		2.00	10. 9.00
Dublin	L. *Arch Biſh.*	7.42.11				9.49.40
Dublin	M. *Hawkins*	7.41.30				9.48.45
Exon	L. *Biſhop*		8.55. 0	8.59. 0	4.00	10. 0.00
Exon	M. *Hudſon*	7.47.30			3.30	10. 0.30
Greenwich	M. *Flamſteed*				3.11	
King's Wald.	M. *Whitſide*				3.52	
Llanidan } *Angleſey*	M. *Rowland*	7.52.30				
London	R. *Society*	8. 6.00	9. 9. 3	9.12.26	3.23	10.20.00
Northampt.	M. *Hawkins*		9. 5.22	9. 9.24	4. 2	10.15.35
Norton-court	D. *Harris*	8. 8.55	9.13.23	9.14.22	0.59	10.24.47
Oxon	D. *Keill*				3.30	10.15.10
Paris	R. *Academy*	8.11.00				10.28.00
Plymouth	M. *Heines*	7.41.00	8.45.30	8.50.00	4.30	9.54.30
Portcheſter	C. *Candler*		9. 2.25	9. 6.15	3.50	
Salop	D. *Hollings*	7.58. 0			1.40	10. 6.00
Upminſter	M. *Derham*	8. 7.41	9.10.58	9.14. 6	3. 8	10.21.45
Wanſted	M. *Pound*	8. 6.37	9. 9.28	9.12.48	3.20	10.20.32
Weymouth	M. *Hobbs*		8.54.00	8.58.00	4.00	
Witley	M. *Baxter*	7.59. 0			3.15	10.13.00

III. *Obſervations of the late* Total Eclipſe *of the* Sun *on the* 22d *of* April *laſt paſt, made before the* Royal Society *at their* Houſe *in* Crane-Court *in* Fleet-ſtreet, London. *By* Dr. Edmund Halley, *Reg. Soc. Secr. With an Account of what has been communicated from abroad concerning the ſame.*

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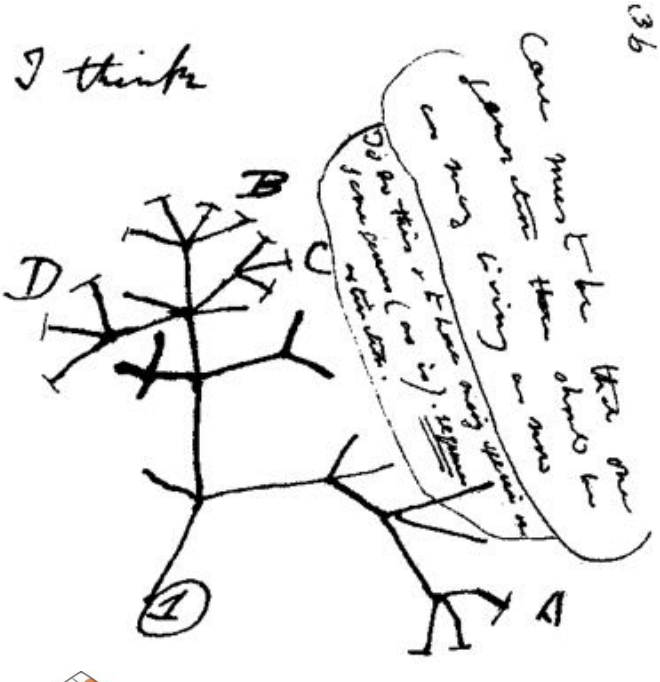
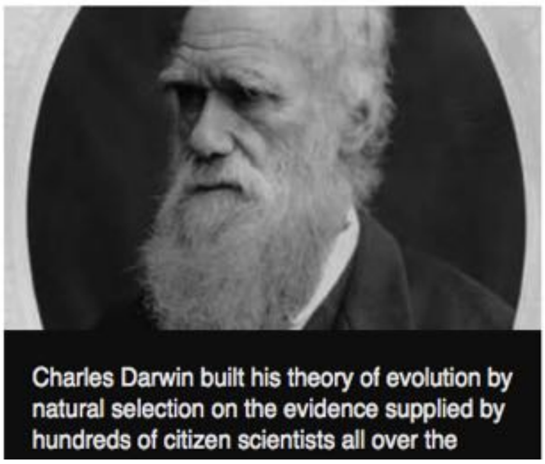
1850s … Charles Darwin





To J. D. Hooker
Down Bromley Kent
12 April [1857]

My dear Hooker

Your letter has pleased me much, for I never can get it out of my head, that I take unfair advantage of your kindness, as I receive all & give nothing. What a splendid discussion you could write on whole subject of variation! The cases discussed in your last note are valuable to me, (though odious & damnable) as showing how profoundly ignorant we are on causes of variation.

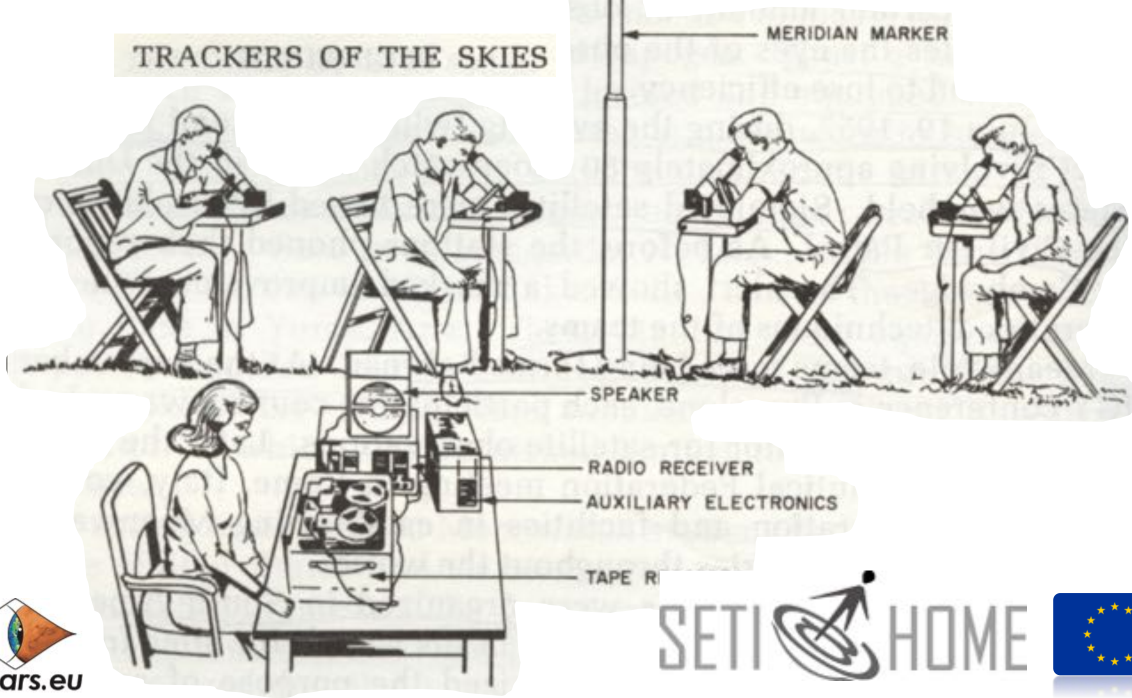
Audobon Society: Bird Counting

What conservationists have learned through Christmas Bird Count data

- Audubon's 2014 Climate Change Report is a comprehensive, first-of-its kind study that predicts how climate change could affect the ranges of 588 North American birds. Of the 588 North American bird species Audubon studied, more than half are likely to be in trouble. Our models indicate that 314 species will lose more than 50 percent of their current climatic range by 2080.
- The Environmental Protection Agency (EPA) has included Audubon's climate change work from CBC data as one of 26 indicators of climate change in their 2012 report.
- In 2009 CBC data were instrumental in the collaborative report by the North American Bird Conservation Initiative, U.S. Fish & Wildlife Service - State of the Birds 2009.
- In 2007, CBC data were instrumental in the development of Audubon's Common Birds in Decline Report, which revealed that some of America's most beloved and familiar birds have taken a nosedive over the past forty years.

Astronomy and Planetary Science

- Moonwatch



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Operation Moonwatch: Terre Haute, IA, USA.

Moonwatch teams would “look up by looking down” using a bench mounted telescope that looked at a reflective plate aimed skyward. With observers arranged in a row aimed at a picket line, they would call out when the target satellite crossed the local meridian. This would in turn be documented by an onsite recorder for transmission. (Ref: Keep Watching the Skies! Author Patrick McCray)

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Fast forward 50 years…

~900,000 galaxies imaged by the Sloan Digital Sky Survey.

~70,000 classifications an hour within 24 hours; **> 50 million classifications** in year one, contributed by **> 150,000 people.**

Mon. Not. R. Astron. Soc. 399, 129–140 (2009) doi:10.1111/j.1365-2966.2009.15299.x

Galaxy Zoo: ‘Hanny’s Voorwerp’, a quasar light echo?*

Chris J. Lintott,[1]† Kevin Schawinski,[1,2,3] William Keel,[4,5]‡ Hanny van Arkel,[6] Nicola Bennert,[7,8] Edward Edmondson,[9] Daniel Thomas,[9] Daniel J. B. Smith,[10] Peter D. Herbert,[11] Matt J. Jarvis,[11] Shanil Virani,[3] Dan Andreescu,[12] Steven P. Bamford,[8] Kate Land,[1] Phil Murray,[13] Robert C. Nichol,[9] M. Jordan Raddick,[14] Anže Slosar,[15] Alex Szalay[14] and Jan Vandenberg[14]

[1] *Department of Physics, University of Oxford, Oxford OX1 3RH*
[2] *Department of Physics, Yale University, New Haven, CT 06511, USA*
[3] *Yale Center for Astronomy and Astrophysics, Yale University, PO Box 208121, New Haven, CT 06520, USA*
[4] *Department of Physics and Astronomy, University of Alabama, Box 870324, Tuscaloosa, AL 35487, USA*
[5] *SARA Observatory, 950 N. Cherry Ave., Tucson, AZ 85719, USA*
[6] *Netherlands School System*
[7] *Institute of Geophysics and Planetary Physics, University of California, Riverside, CA 92521, USA*
[8] *Physics Department, University of California, Santa Barbara, CA 93106, USA*
[9] *Institute of Cosmology & Gravitation, Denis Sciama Building, University of Portsmouth, Burnaby Road, Portsmouth PO1 3FX*
[10] *Astrophysics Research Institute, Liverpool John Moores University, Twelve Quays House Egerton Wharf, Birkenhead CH41 1LD*
[11] *Centre for Astrophysics, Science & Technology Research Institute, University of Hertfordshire, Hatfield AL10 9AB*
[12] *LinkLab, 4506 Graystone Ave., Bronx, NY 10471, USA*
[13] *Fingerprint Digital Media, 9 Victoria Close, Newtownards, Co. Down, Northern Ireland BT23 7GY*
[14] *Department of Physics and Astronomy, Johns Hopkins University, 3400 N. Charles St., Baltimore, MD 21218, USA*
[15] *Berkeley Centre for Cosmological Physics, Lawrence Berkeley National Laboratory and Physics Department, Berkeley, CA 94720, USA*

ABSTRACT

We report the discovery of an unusual object near the spiral galaxy IC 2497, discovered by visual inspection of the Sloan Digital Sky Survey (SDSS) as part of the Galaxy Zoo project. The object, known as Hanny’s Voorwerp, is bright in the SDSS *g* band due to unusually strong [O III]4959, 5007 emission lines. We present the results of the first targeted observations of the object in the optical, ultraviolet and X-ray, which show that the object contains highly ionized gas. Although the line ratios are similar to extended emission-line regions near luminous active galactic nucleus (AGN), the source of this ionization is not apparent. The emission-line properties, and lack of X-ray emission from IC 2497, suggest either a highly obscured AGN with a novel geometry arranged to allow photoionization of the object but not the galaxy’s own circumnuclear gas, or, as we argue, the first detection of a quasar light echo. In this case, either the luminosity of the central source has decreased dramatically or else the obscuration in the system has increased within 10^5 yr. This object may thus represent the first direct probe of quasar history on these time-scales.

Key words: galaxies: active – galaxies: individual: IC 2497 – galaxies: peculiar – quasars: general.

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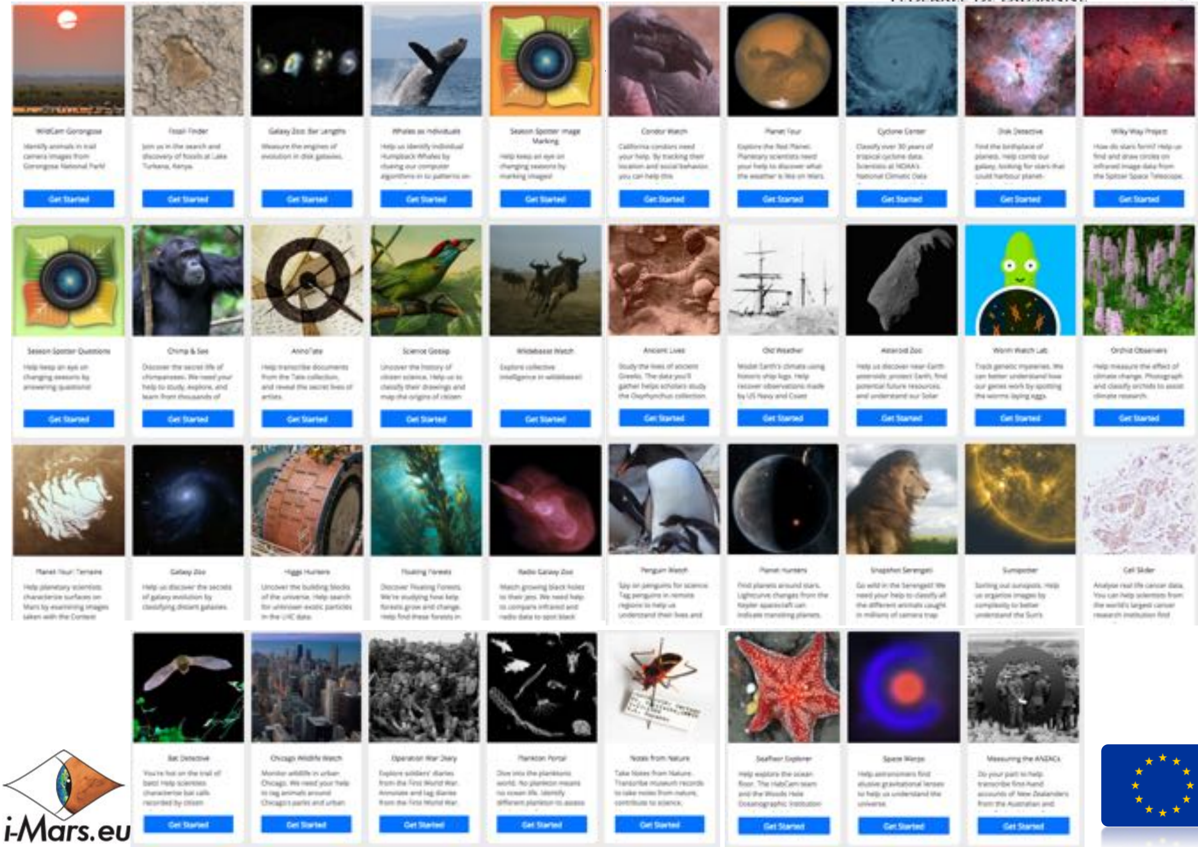
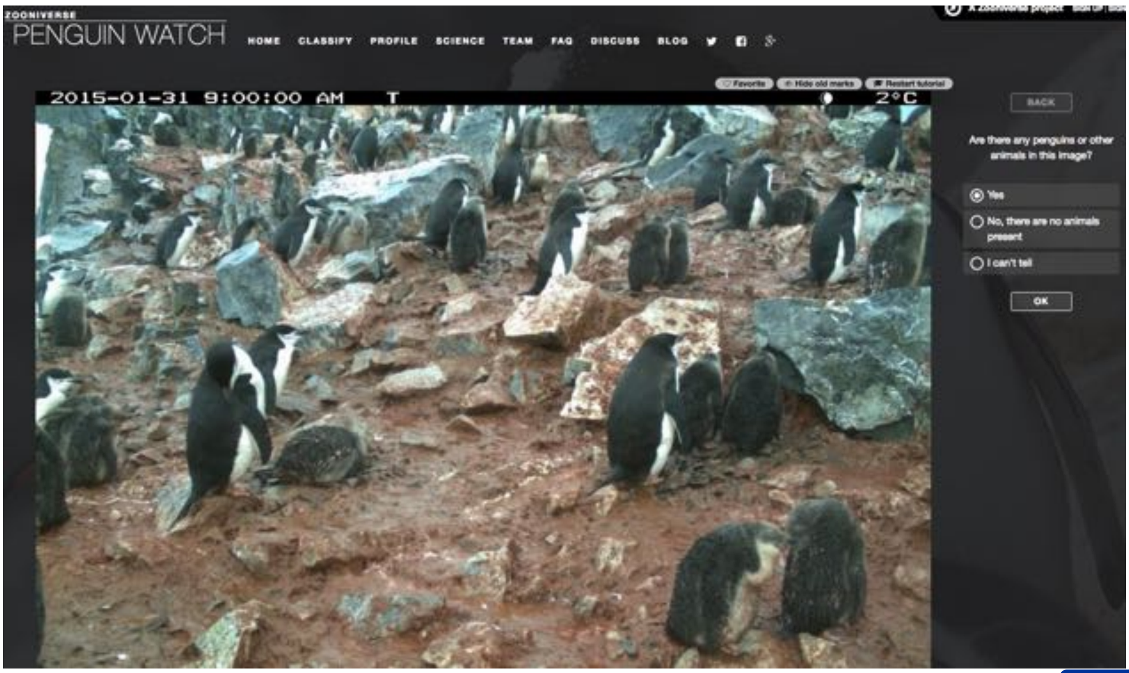


jessica.wardlaw@nottingham.ac.uk

PENGUINS!!!



https://www.penguinwatch.org/#/

jessica.wardlaw@nottingham.ac.uk
Version: 08/06/16

Levels of Participation: Haklay (2013)

'Extreme/ Up-Science'	• Collaborative science – problem definition, data collection and analysis
'Participatory science'	• Participation in problem definition and data collection
'Distributed intelligence'	• Citizens as basic interpreters
'Crowdsourcing'	• Citizens as sensors

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Scientific Results

Computers Would Never Have Found "Alien Superstructure" Star--It Required Citizen Science

Volunteer astronomers first spotted a strange star in Kepler telescope data that has the Internet humming with speculation

By Jennifer Hackett | October 21, 2015

A mysterious star may have comets of its own, similar to the comet Hale-Bopp around the sun, pictured here

Courtesy of Dan Schechter, NASA

Last week the internet was abuzz with rumors of a strange star that some suggested might host an extraterrestrial construction. Astronomers say that scenario is a slim possibility. A more likely explanation is that the weird star, called KIC 8462852, is orbited by a swarm of comets, which is a pretty interesting idea on its own. But either way, this intriguing star might never have been found. The oddball was just one of thousands of stars being monitored by NASA's Kepler telescope, which searches for the telltale dips in a star's light caused when exoplanets pass in front of it. Computers spot most of the promising planet candidates in the data, but this star would have fallen through the cracks if volunteer citizen scientists had not flagged its unusual signature. "This wouldn't have been picked up by a computer algorithm," says Yale University astronomer Tabetha Boyajian, who manages the Planet Hunters crowdsourcing project to analyze Kepler's data. "We weren't looking for something like this."

SCIENTIFIC AMERICAN™

http://www.scientificamerican.com/article/computers-would-never-have-found-alien-superstructure-star-it-required-citizen-science/

biology letters

Biol. Lett. (2011) 7, 168–172
doi:10.1098/rsbl.2010.1056
Published online 22 December 2010

Animal behaviour

Blackawton bees

P. S. Blackawton[1], S. Airzee[1], A. Alle... A. Berrow[1], C. Blair[1], M. Churchill[1], J... J. Cumming[1], L. Fraquelli[1], C. Hackfo... Mellor[1], M. Hutchcroft[1], B. Ireland[1], ... A. Littlejohns[1], G. M. Littlejohns[1], M... J. McKeown[1], A. O'Toole[1], H. Richards[1], L. Robbins-Davey[1], S. Roblyn[1], H. Rodwell-Lynn[1], D. Schenck[1], J. Springer[1], A. Wishy[1], T. Rodwell-Lynn[1], D. Strudwick[1] and R. B. Lotto[2,*]

[1]Blackawton Primary School, Blackawton, Devon, UK
[2]Institute of Ophthalmology, University College London, 11-43 Bath Street, London EC1V 9EL, UK
*Author for correspondence

Background: Real science has the potential to ...

inaccessible to the literate ability of 8- to 10-year-old children, and second, the true motivation for any scientific study (at least one ...

Principal finding: 'We discovered that bumble-bees can use a combination of colour and spatial relationships in deciding which colour of flower to forage from. We also discovered that science is cool and fun because you get to do stuff that no one has ever done before. (Children from Blackawton)'.

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Keywords: *Bombus terrestris*; buff-tailed bumble-bee; visual perception; colour vision; behaviour

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Machine Learning Classification of SDSS Transient Survey Images

L. du Buisson[1,2*], N. Sivanandam[2]†, Bruce A. Bassett[1,2,3]‡ and M. Smith[4,5]

[1]Department of Mathematics and Applied Mathematics, University of Cape Town, Cross Campus Rd, Rondebosch 7700, South Africa
[2]African Institute for Mathematical Sciences, 6-8 Melrose Rd, Muizenberg 7945, South Africa
[3]South African Astronomical Observatory, Observatory Rd, Observatory 7925, South Africa
[4]Department of Physics, University of the Western Cape, Cape Town, 7535, South Africa
[5]School of Physics and Astronomy, University of Southampton, Southampton, SO17 1BJ, United Kingdom

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Using machine learning for discovery in synoptic survey imaging data

Henrik Brink,[1*] Joseph W. Richards,[1,2] Dovi Poznanski,[3] Joshua S. Bloom,[1] John Rice,[2] Sahand Negahban[4] and Martin Wainwright[2,4]

[1]Department of Astronomy, University of California Berkeley, Berkeley, CA 94720, USA
[2]Department of Statistics, University of California Berkeley, Berkeley, CA 94720, USA
[3]School of Physics and Astronomy, Tel Aviv University, Tel Aviv 6997801, Israel
[4]Department of Electrical Engineering and Computer Sciences, University of California Berkeley, Berkeley, CA 94720, USA

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Scientific Results

The Moon Zoo citizen science project: Preliminary results for the Apollo 17 landing site

CrossMark

Roberto Bugiolacchi[a,*], Steven Bamford[b], Paul Tar[c], Neil Thacker[c], Ian A. Crawford[a], Katherine H. Joy[d], Peter M. Grindrod[a], Chris Lintott[e]

[a] Department of Earth and Planetary Sciences, Birkbeck College, University of London, Malet Street, London, WC1E 7HX, UK
[b] School of Physics & Astronomy, The University of Nottingham, University Park, Nottingham, NG7 2RD, UK
[c] Centre for Imaging Sciences, University of Manchester, Stopford Building, Oxford Road, Manchester M13 9PT, UK
[d] School of Earth, Atmospheric and Environmental Sciences, University of Manchester, Oxford Road, Manchester, M13 9PL, UK
[e] Department of Physics, University of Oxford, Keble Road, Oxford, OX1 3RH, UK

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ABSTRACT

Moon Zoo is a citizen science project that utilises internet crowd-sourcing techniques. Moon Zoo users are asked to review high spatial resolution images from the Lunar Reconnaissance Orbiter Camera (LROC), onboard NASA's LRO spacecraft, and perform characterisation such as measuring impact crater sizes and identify morphological 'features of interest'. The tasks are designed to address issues in lunar science and to aid future exploration of the Moon. We have tested various methodologies and parameters therein to interrogate and reduce the Moon Zoo crater location and size dataset against a validated expert survey. We chose the Apollo 17 region as a test area since it offers a broad range of cratered terrains, including secondary-rich areas, older maria, and uplands. The assessment involved parallel testing in three key areas: (1) filtering of data to remove problematic mark-ups; (2) clustering methods of multiple notations per crater; and (3) derivation of alternative crater degradation indices, based on the statistical variability of multiple notations and the smoothness of local image structures. We compared different combinations of methods and parameters and assessed correlations between resulting crater summaries and the expert census.

We derived the optimal data reduction steps and settings of the existing Moon Zoo crater data to agree with the expert census. Further, the regolith depth and crater degradation states derived from the data are also found to be in broad agreement with other estimates for the Apollo 17 region. Our study supports the validity of this citizen science project but also recommends improvements in key elements of the data acquisition planning and production.

Citizen Science in Astronomy

Observations

- Active e.g. discovery & characterisation of asteroids and comets, long-term planetary monitoring, Solar System Impacts, Transiting and Microlensing Exoplanets, Variable Star Monitoring.
- Passive e.g. The Orbit of Comet Holmes: Flickr photos.

Visual Classification

- Stardust@home, Galaxy Zoo etc
- MoonZoo, Moon Watch.
- Planet Hunters, Supernova Zoo etc.
- Classification analysis e.g. Space Warps

Citizen Science in Astronomy

Data modeling

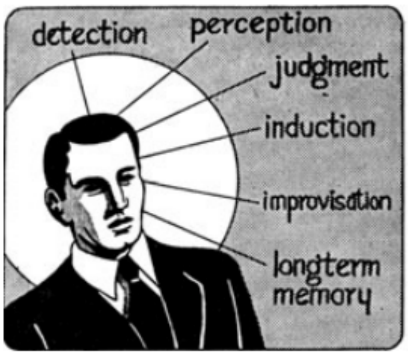
- Milky Way Project, Galaxy Zoo: Mergers, Space Warps, FoldIt etc.

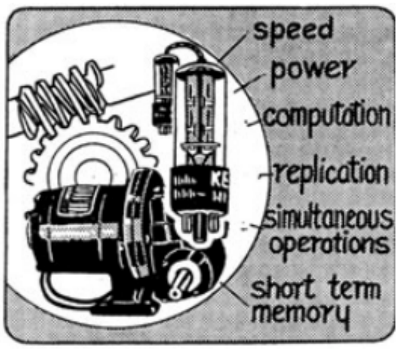
Citizen-led enquiry

- e.g. Solar Storm Watch.

iMars: Unknowns (both known *and* unknown)

- The surface of Mars is in flux;
  - **BUT** we don't the extent of the changes: what (features), how (many), where, when etc etc…
- No ground truth **and** resource intensive: for humans & computers





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Work design for a repetitious task

	CROWD	COMPUTER
PROS	Flexible. Learn experientially. '*Wisdom* of the crowd' (Consensus). Improvise in ingenious ways. Millions of years of evolution.	Controllable. Accountable. Consistent. Calibrated. Evolve quickly.
CONS	Tiredness. Ethical considerations. Performance affected in ways we may never fully understand (e.g. task design). Biased (demographics, imagery, features) Malicious. Genuine Errors. Inconsistent.	Takes time – to program and process. *Already tried and failed on Mars:* *River networks (Stepinski & Collier, 2004); Craters (Bue & Stepinski, 2007); Sand dunes (Bandeiraet et al. 2009)* Only does what you ask it to. Expensive.

We can't do this alone.

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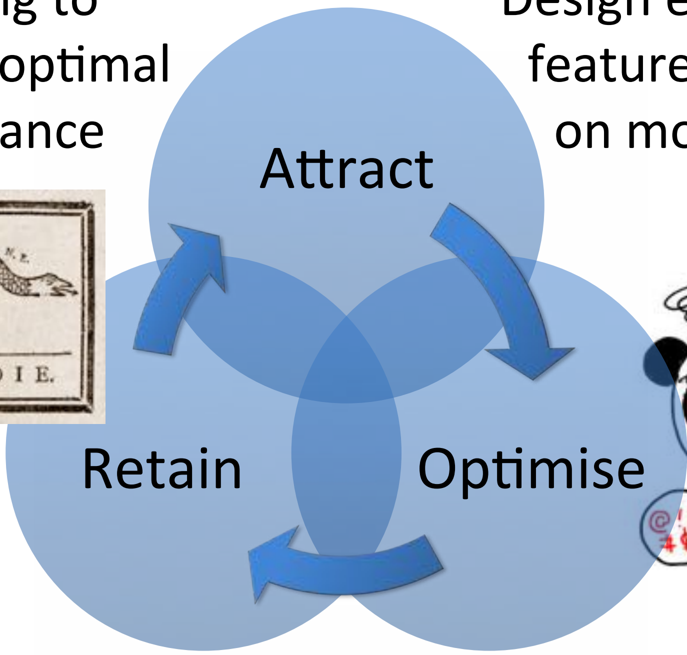
What are the main issues for crowd work?

Designing to encourage optimal performance

Design elements & features' impact on motivation



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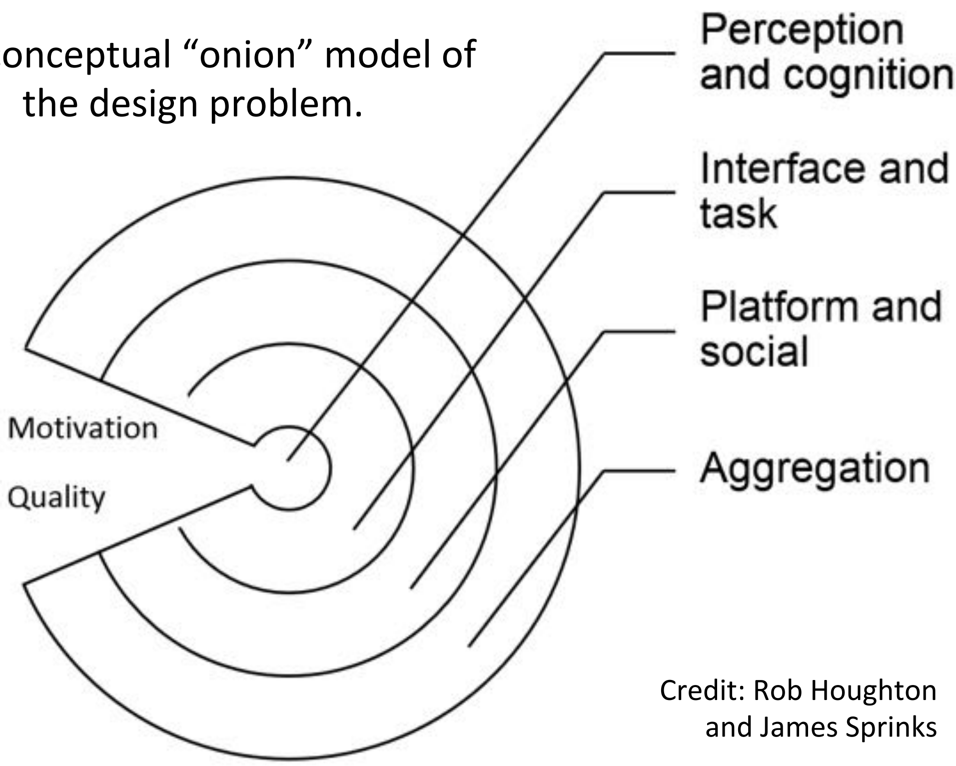
The iMars Challenge: Crowd Control

Our conceptual "onion" model of the design problem.



Credit: Rob Houghton and James Sprinks

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Feature detectability at different resolutions of Mars dynamic features

FEATURE	SCALE			
	1 – <10 m[(a)]	10 – <50 m[(b)]	50 – <100 m[(c)]	100 – <1000 m[(d)]
Polar Pits	•			
Avalanches		•	•	•
Polygons	•	•		
RSL	•	•		
Swiss Cheese Terrain		•	•	
Active Gullies	•	•	•	
Dunes	•	•	•	
Impact Craters	•	•	•	•
Dust Devils	•	•	•	
Spiders	•	•		

a: MRO/HiRISE, potentially some MRO/CTX and MGS/MOC cPROTO
b: MRO/CTX and MGS/MOC, MO/THEMIS VIS, MEx/HRSC, VO Imaging
c: MO/THEMIS VIS, MEx/HRSC, VO Imaging
d: MO/THEMIS VIS, MO/THEMIS IR, MEx/HRSC, VO VIS Imaging, M9 VIS

Thanks to James Sprinks

Change blindness

ECSA 10 Principles

1. Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.
2. Citizen science projects have **a genuine science outcome**.
3. Both the **professional scientists and the citizen scientists benefit** from taking part.
4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process.
5. Citizen scientists receive feedback from the project.
6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.
7. Citizen science project data and meta-data are made publicly available and where possible, results are published in an open access format.
8. Citizen scientists are acknowledged in project results and publications.
9. Citizen science programmes are **evaluated for their scientific output**, data quality, participant experience and wider societal or policy impact.
10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.

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Calibration/Validation with expert data

OPEN

SUBJECT CATEGORIES
» Community ecology
» Population dynamics
» Biodiversity

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Published: 9 June 2015

Snapshot Serengeti, high-frequency annotated camera trap images of 40 mammalian species in an African savanna

Alexandra Swanson[1,2], Margaret Kosmala[1,†], Chris Lintott[2], Robert Simpson[2], Arfon Smith[3] & Craig Packer[1]

Camera traps can be used to address large-scale questions in community ecology by providing systematic data on an array of wide-ranging species. We deployed 225 camera traps across 1,125 km² in Serengeti National Park, Tanzania, to evaluate spatial and temporal inter-species dynamics. The cameras have operated continuously since 2010 and had accumulated 99,241 camera-trap days and produced 1.2 million sets of pictures by 2013. Members of the general public classified the images via the citizen-science website www.snapshotserengeti.org. Multiple users viewed each image and recorded the species, number of individuals, associated behaviours, and presence of young. Over 28,000 registered users contributed 10.8 million classifications. We applied a simple algorithm to aggregate these individual classifications into a final 'consensus' dataset, yielding a final classification for each image and a measure of agreement among individual answers. The consensus classifications and raw imagery provide an unparalleled opportunity to investigate multi-species dynamics in an intact ecosystem and a valuable resource for machine-learning and computer-vision research.

Swanson, A. et al. Snapshot Serengeti, high-frequency annotated camera trap images of 40 mammalian species in an African savanna. Sci. Data 2:150026 doi: 10.1038/sdata.2015.26 (2015).

Technical Validation

We asked five researchers with extensive wildlife identification experience to classify 4,149 randomly selected image sets containing animals using the *Snapshot Serengeti* interface; 263 image sets received two expert classifications and 8 image sets received three, for a total of 4,428 classifications. The experts noted whether any image sets were especially difficult or whether they thought the image was identifiable at all.

Aim 1: You will help us keep the crowd in check

The variability of crater identification among expert and community crater analysts

Stuart J. Robbins[a,*], Irene Antonenko[b,c], Michelle R. Kirchoff[d], Clark R. Chapman[d], Caleb I. Fassett[e], Robert R. Herrick[f], Kelsi Singer[g], Michael Zanetti[g], Cory Lehan[h], Di Huang[h], Pamela L. Gay[h]

[a] Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, 3665 Discovery Dr., Boulder, CO 80309, United States
[b] Planetary Institute of Toronto, 197 Fairview Ave., Toronto, ON M6P 3A6, Canada
[c] University of Western Ontario, 1151 Richmond Street N., London, ON N6A 5B7, Canada
[d] Southwest Research Institute, 1050 Walnut Street, Suite 300, Boulder, CO 80302, United States
[e] Department of Astronomy, Mount Holyoke College, 50 College Street, South Hadley, MA 01075, United States
[f] Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320, United States
[g] Department of Earth and Planetary Sciences, McDonnell Center for the Space Sciences, Washington University in St. Louis, 1 Brookings Dr., Saint Louis, MO 63130, United States
[h] The Center for STEM Research, Education, and Outreach at Southern Illinois University, Edwardsville, Edwardsville, IL 62025, United States

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ABSTRACT

The identification of impact craters on planetary surfaces provides important information about their geological history. Most studies have relied on individual analysts who map and identify craters and interpret crater statistics. However, little work has been done to determine how the counts vary as a function of technique, terrain, or between researchers. Furthermore, several novel internet-based projects ask volunteers with little to no training to identify craters, and it was unclear how their results compare against the typical professional researcher. To better understand the variation among experts and to compare with volunteers, eight professional researchers have identified impact features in two separate regions of the Moon. Small craters (diameters ranging from 10 m to 500 m) were measured on a lunar mare region and larger craters (100s m to a few km in diameter) were measured on both lunar highlands and maria. Volunteer data were collected for the small craters on the mare. Our comparison shows that the level of agreement among experts depends on crater diameter, number of craters per diameter bin, and terrain type, with differences of up to ~±45%. We also found artifacts near the minimum crater diameter that was studied. These results indicate that caution must be used in most cases when interpreting small variations in crater size-frequency distributions and for craters ≲10 pixels across. Because of the natural variability found, projects that emphasize many people identifying craters on the same area and using a consensus result are likely to yield the most consistent and robust information.

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Aim 2: Training a change detection algorithm

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Space Warps: II. New Gravitational Lens Candidates from the CFHTLS Discovered through Citizen Science

Anupreeta More,[1*] Aprajita Verma,[2] Philip J. Marshall,[2,3] Surhud More,[1]
Elisabeth Baete
Amit Kapadia,[5]
Raphael Gavazz ... ith,[4]
Edward Paget,[4]

[1] *Kavli IPMU (WPI), U*
[2] *Dept. of Physics, Unive*
[3] *Kavli Institute for Part*
[4] *Zooniverse, c/o Astroph*
[5] *Adler Planetarium, Chi*
[6] *Institut dAstrophysique*
[7] *Department of Physics,*
[8] *Institute of Cosmology*

ABSTRACT

We report the discovery of 29 promising (and 59 total) new lens candidates from the CFHT Legacy Survey (CFHTLS) based on about 11 million classifications performed by citizen scientists as part of the first Space Warps lens search. The goal of the blind lens search was to identify lens candidates missed by robots (the RingFinder on galaxy scales and ArcFinder on group/cluster scales) which had been previously used to mine the CFHTLS for lenses. We compare some properties of the samples detected by these algorithms to the Space Warps sample and find them to be broadly similar. The image separation distribution calculated from the Space Warps sample shows that previous constraints on the average density profile of lens galaxies are robust. Space Warps recovers about 65% of known lenses, while the new candidates show a richer variety compared to those found by the two robots. This detection rate could be increased to 80% by only using classifications performed by expert volunteers (albeit at the cost of a lower purity), indicating that the training and performance calibration of the citizen scientists is very important for the success of Space Warps. In this work we present the SIMCT pipeline, used for generating *in situ* a sample of realistic simulated lensed images. This training sample, along with the false positives identified during the search, has a legacy value for testing future lens finding algorithms. We make the pipeline and the training set publicly available.

Key words: gravitational lensing: strong – methods: statistical – methods: citizen science

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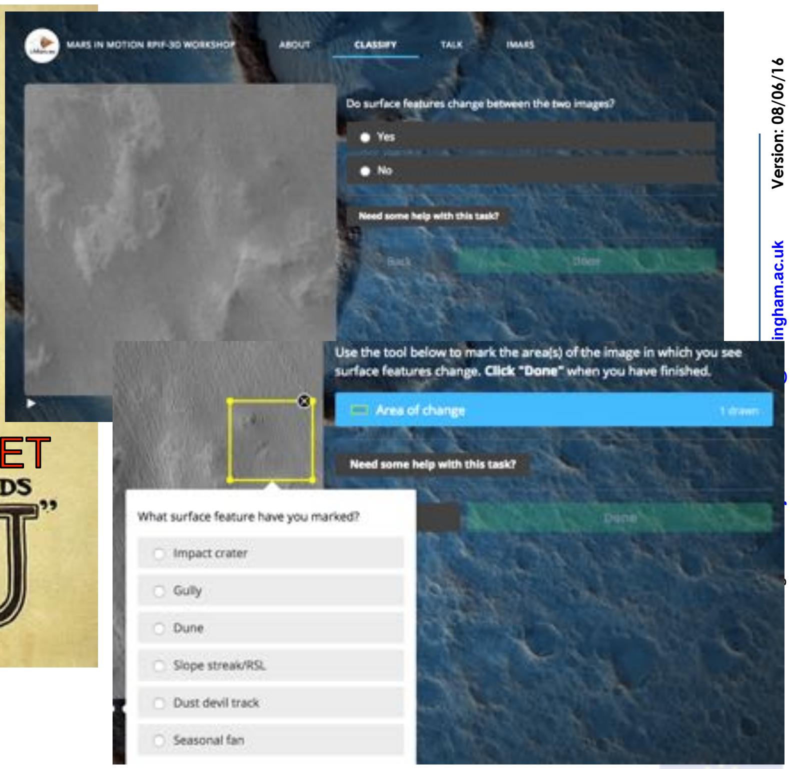
Donald Rumsfeld

"Reports that say that something hasn't happened are always interesting to me, because as we know, there are **known knowns**; there are things we know we know. We also know there are **known unknowns**; that is to say we know there are some things we do not know. But there are also **unknown unknowns** - the ones we don't know we don't know. And if one looks throughout the history of our country and other free countries, it is the latter category that tend to be the difficult ones."

Unknown or known, help us find our unknowns!



Schedule

- **Next:** Panos will introduce you to the automated co-registration and orthorectification algorithm which provides the input data for your training.
- **Then:** Introduction to your mission - Register on www.zooniverse.org and **sign consent**.

LUNCH

- **THE FUN BEGINS**

https://www.zooniverse.org/projects/imarsnottingham/mars-in-motion-rpif-3d-workshop

https://nottingham.onlinesurveys.ac.uk/mars-in-motion-rpif-3d-workshop

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jessica.wardlaw@nottingham.ac.uk
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