Automated Feature Description

Question 1: What are the strengths of this approach to boulder mapping or rock counting?

Group A

Person 1

* Saves schedule (By 3 orders of magnitude)

* More complete (potentially); fewer missed boulders

* Immediately Quantifiable

* Scaleable - it can work at all size scales and with a little bit of human input it can process a region efficiently

(schedule savings reduced a little by it but more applicable to different size scales)

* Quality of the results has the potential to degrade gracefully — we might not get a perfect count, but we’ll get some useful information

Person 2

* Can be very fast

* Extremely popular field right now, lots of people studying it and developing it

* It’s popular technology, so people outside of space sciences enthusiasts / professionals will be drawn to the research results

* Can be versatile and tailored for different scenarios

Person 3

* Potential connection with autonomous reasoning (Artificial Intelligence) to _____ of large asteroid database

Group B

Person 1

* Can quickly analyze large amounts of data (only limited by computer processing)

* No human error or bias

* No choice for human to make on whether or not something is a boulder

* Can use multiple methods pr approaches to validate/check the other

Person 2

* Reproduce results easily, and different hypothesis is easily tested

* Algorithms can be published, as well as as detection criteria

* Algorithms can be improved

* Results are often “Good enough” for quick assessment of terrain, top-level science

Person 3

* Once developed, can be modified for other NASA missions

* Re-enforces the relationships between space sciences and computer science

Group C

Person 1

* Clearly, applying computer vision methods offers the opportunity to rapidly assess sampleability and hazards - TIME SAVINGS

* Lower cost

* Commissioning of results

* Likely to create trust by stakeholders (NASA HQ) if results can be validated by human counters

Person 2

* Quick

* Unbiased (Maybe)

==> trust

    ==> operator independent

Person 3

* Maybe well suited to quick look triaging of the data - could provide an initial assessment of where to focus manual efforts

Person 4

* Can be run uniformly over whole surface - no person - dependent regional biases. Objective.

Question 2: What are the weaknesses of this approach to boulder mapping or rock counting?

Group A

Person 1

* Large number of techniques are available with pro's and con's —> hard to do the input selection

* Potential for ____ various techniques but unclear how

Person 2

* Time limit to verification process

* Potential to waste a lot of time making algorithm combinations for scenarios we won't encounter

* Might need a lot of manual input anyway

* Could be very dependent on or affected by image quality / change

Person 3

* Complex boulder fields may produce nonsensical results

Group B

Person 1

* Potential for false detections and missed identifications

* Non—negligible ramp up time for method development and pipeline creation

* Relatively new process for analysis

Person 2

* Not Flexible - Complications are difficult to deal with

* Algorithm improvement or modifications non-trivial to in many cases

* Poor data will limit usefulness of results, perhaps more than human counts

* May not be able to fully test algorithm prior to seeing Bennu - unknown if it will work well.

Group C

Person 1

* May be difficult to create a robust algorithm for all scales, terrains and lighting conditions

* The robustness may come at the identical cost of many counting bodies

* need to develop quality control checks and processes

Person 2

* Difficult to reproduce Bennu conditions pre-encounter

* Validation and verification will be a challenge to demonstrate that we can meet requirements

Person 3

* Will it work will enough that we trust it?

* Will it work on a dark surface>

* Does it depend on the nature of the feature?

* Do the methods that work depend on the surface?

* Does if have size dependent errors that we won’t be able to quantify?

Person 4

* Not clear which techniques would be most effective before you get to the asteroid.

* It appears various techniques have strengths / weaknesses that vary by terrain

* Could provide a false sense of confidence without manual counts

Question 3: Are there any opportunities we can leverage to improve this approach?

Group A

Person 1

* Continue researching uses in other missions including Mars

* Are there other industries using this technology for similar uses? mining?

* incorporate machine learning into the process

Person 2

* Look at the problem of face recognition in machine learning —> similar problem to the identification of faces

—> maybe an opportunity —> this is machine learning based.

Person 3

* By putting a human in the lop, you can improve the technique or tune it to the particular planetary surface/asteroid surface / lighting geometry being processed

* Developing refining an automated technique will have implications for planetary studies in general; the pay off is big, so it's worth putting resources into it.

Group B

Person 1

* Ideally, this can be tested using large dataset from Eros

* Set up challenge to improve algorithm using young computer scientists

* Show results at conference with access to experts

Person 2

* Can test this approach in the lunar datasets where LROC has done manual boulder counts and Diviner has rock abundance calculated for thermal infrared data

Person 3

* Engage the computer science community!

Person 4

* Itokawa studies

* Really need to develop edge case terrain for simulations

Group C

Person 1

* Issue a software challenge on the internet for algorithm optimization - choose a winner for additional support and refinement

* Explore ways to merge the different solutions and increase the success rate

* Hire Carina after graduation to work on this full time

* Combine with stereo imaging and develop software based in 3-D analysis

Person 2

* If multiple methods give a similar result we are likely to trust them.

* Combine with partial manual counts

Person 3

* Combine this technique with (partial) human counts. Like Catalina Sky Survey, have humans finish the job — let the computer do the first 70% of the work.

* Try to get the Comp. Sci. department involved

* Schedule a software challenge (like the asteroid challenge) - a top coder challenge

Question 4: What testing can we do to validate this approach?

Group A

Person 1

* Compare regions counted automatically with regions counted manually

a) synthetic boulder fields

b) Itokawa boulder fields

c) Eros boulder fields

* Degrade planetary or asteroid surfaces and attempt a census

Person 2

* This is a multi-scale problem => can you detect rocks at different scales? Ned to have an idea how the algorithms are robust to scaling

Person 3

* Compare against manually counted areas

* Test multiple algorithms and combinations against the same dataset for check individual and combined accuracy

Group B

Person 1

* Can test against manual counts for a given region

* Different algorithms can be tested against on another

* Can test against manual counts for a given region with different sun angles to test how that changes automated results

Person 2

* Can test in terrestrial / lunar data to gain confidence in algorithm

Group C

Person 1

* Global and regional analysis of Itokawa

* Compare to previous studies and human counts

* Test on a variety of simulated terrain

* Lighting is important — test various phase angles to understand sensitivity

Person 2

* Apply error to ____ images and see how it affects results

Person 3

* Apply the techniques to Itokawa, Rosetta data although theses is no guarantee that your tests will validate what you find at Bennu, unless you get unacceptable results for all tests, then you are free to abandon approach

Person 4

* Generate simulated images with known artifacts to quantify ways that the techniques can be fooled.

* Analyze Mars landing sites to reproduce hazard assessments

Person5

Question 5: Are there other issues, questions, ideas that are not covered by the strengths, weaknesses, opportunities, and testing questions? (wildcard)

Group A

Person 1

* I would look more closely at the literature: ++> most of the readings are from 2005-2007 and ___ a JPL-based ___. No results publication is found

* Note that most of the cited algorithms are available also in the Image processing toolbox in MATLAB.

* Need to define a testing campaign for evaluation of algorithms

Person 2

* How many people might we need to develop this technology? What kind of specialized training should they have.

* Opportunities to meet with people working on this currently?

Person 3

* This technique degrades gracefully: a partial answer is a step forward and when combined with other techniques can produce an advance

Group B

Person 1

* How will the final method to be used be determined?

* Will multiple methods be used?

* Does this require a lot of storage and processing power?

Person 2

* What are the tradeoffs between different automated approaches and increasing spatial resolution?

Person 3

* Some algorithms are already in use, with experts knowing strengths, weaknesses

* Hard to anticipate "Unknown Unknowns"

Group C

Person 1

* Not clear how the various methods would be validated before we get to the asteroid

* Techniques show promise, but its not clear which techniques wold be best, so one would have to try them all.

Person 2

* Technique would need to be validated with real data from Bennu — the project is likely to be hesitant to trust the results without validation of actual data from the asteroid

Person 3

* Best method likely depends on nature of surface which we don't know

Person 4

* We need to develop a method to quantify the size of the idnet. objects +> impacts ability to model a power law

Person 5