Gigapan Voyage for Robotic Recon

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ABSTRACT

Gigapan Voyage (GV) is a self-contained remotely-operable Gigapan capturing system that is currently being developed by the Intelligent Robotics Group (IRG) at NASA Ames Research Center. Gigapan Voyage was primarily designed to be integrated onto Johnson Space Center's Lunar Electric Rovers (LER). While on LER, Gigapan Voyage was used by scientists and astronauts during the 2009 and 2010 Desert RATS field tests.

The concept behind Gigapan Voyage is to merge all the sub-components of the commercial GigaPan system into an all-in-one system that can capture, stitch, and display Gigapans in an automated way via a simple web interface. The GV system enables NASA to quickly and easily add remote-controlled Gigapan capturing capability onto rovers with minimal integration effort.

Keywords

Geology, NASA, Black Point Lava Flow, Robot, K10, LER, Gigapan Voyage, Desert RATS, Intelligent Robotics Group

INTRODUCTION

Gigapan Voyage (GV) is a web-controllable, stand-alone Gigapan capturing, stitching, and browsing system developed at NASA Ames Research Center by the Intelligent Robotics Group. In 2009, the Gigapan Voyage system was installed on Johnson Space Center's Lunar Electric Rover (LER) for the Desert Research and Technology Studies (D-RATS) field test. During the two and half week field test approximately 275 Gigapans were captured by the science and astronaut teams.

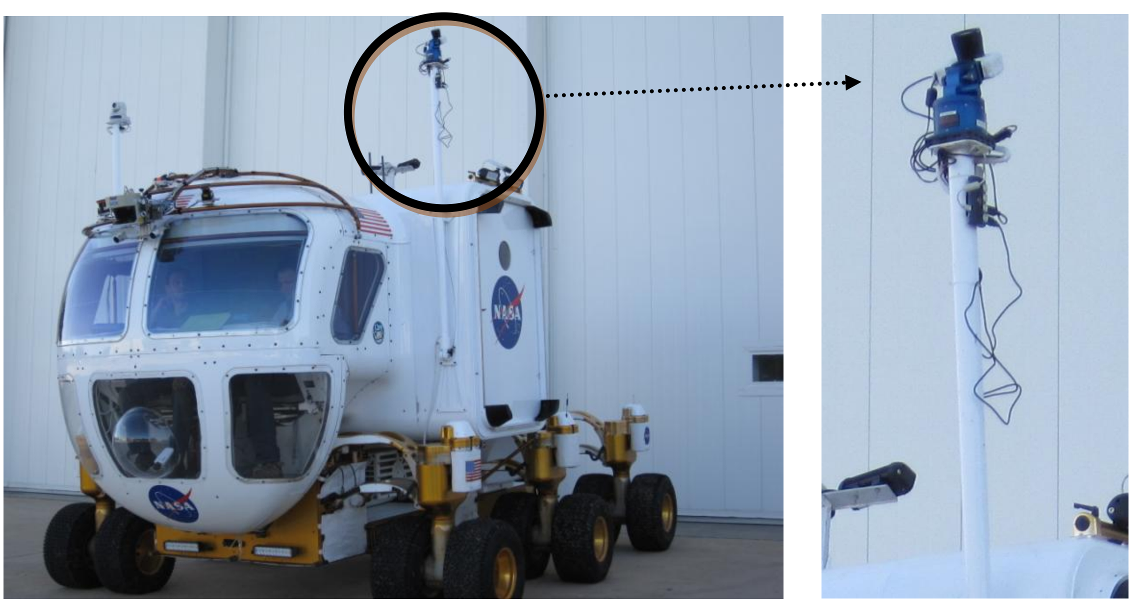

Figure 1: Gigapan Voyage mounted on the Lunar Electric Rover in 2010

Gigapan Voyage encapsulates all the sub-components of the commercial GigaPan system and delivers an all-in-one package that can be remotely controlled via a simple web-interface. By designing the system in this way, integration onto the two Lunar Electric Rovers only required mounting the hardware, accessing power from the vehicle, and connecting the system to the vehicle's on-board wireless network, thus significantly cutting down on cross-center integration effort.

Background

Robotic Recon Experiment

During August and September of 2009, the Intelligent Robotics Group (IRG) completed a "robotic recon" experiment as part of the 2009 Desert Research and Technology Studies (D-RATS) field test at Black Point Lava Flow, Arizona. The objective of the "robotic recon experiment" was to improve NASA's understanding of how pre-cursor robotic scouting could enhance planning capabilities and increase science return from human exploration missions.

Two months earlier in June 2009, IRG used their K10 mobile robot equipped with multiple cameras and a 3D scanning laser to scout portions of Black Point Lava Flow. The data collected by K10 included Gigapan-like images that were subsequently used in the summer of 2009 to plan traverses designed to help establish the geologic history of the site.

During the D-RATS field test, two-man crews carried out traverses using the Lunar Electric Rover and simulated Extra Vehicular Activity (EVA) suits. Two of the traverses were planned using only satellite images. Two other traverses were based on satellite images and the ground-level robotic recon data previously collected by K10. Assessment of the differences (in planning, execution, and science return) between the different traverses will provide insight into the usefulness of robotic recon. (Gigapan Voyage Field Tested at 2009 "Desert Rats", 2009)

During this two and a half week field experiment, approximately 275 Gigapans were captured using the Gigapan Voyage system.

Desert Research and Technology Studies (DRATS)

The D-RATS project is a NASA-led team of research partners working together to prepare for human-robotic exploration of remote planetary surfaces. The Desert RATS field test activities are the culmination of the various individual science and advanced engineering discipline areas into a coordinated demonstration. These demonstrations take place at locations on the Earth that are similar in terrain to other planetary surfaces such as the Moon. The purpose of the D-RATS effort is to assess preliminary exploration operational concepts, including rovers, EVA time lines, and ground support.

D-RATS activities also are of significant importance in helping to develop the necessary levels of technical skills and experience for the next generation of engineers, scientists, technicians, and astronauts who will be responsible for realizing the goals of the Constellation Program. (Desert RATS Overview)

SAMPLE GIGAPANS CAPTURED DURING 2009 DRATS FIELD TEST

Figure 2 Image take by Gigapan Voyage from Black Point Lava Flow Field Test 2009: For more detail, see http://gigapan.org/gigapans/32871/

Figure 3 Gigapan from field test: For more detail, http://gigapan.org/gigapans/32848/

Figure 4 Image from field test: For more detail, http://gigapan.org/gigapans/32832/

Figure 5 Inside of the Robot Shelter Area at Base Camp http://gigapan.org/gigapans/32812/

HARDWARE

The Gigapan Voyage hardware currently consists of the following components:

- TracLabs Biclops Pan-Tilt Unit – This particular unit was chosen due to speed, payload rating, and encoder feedback capability, but any remotely-controllable pan-tilt unit can be used.
- Canon G7/G9 Camera – Any camera supported by the gPhoto[1] open-source library can be used.
- Commercial low-cost USB GPS unit, GlobalSat, Part #BU-353
- Small USB hub, Part #PA055U
- Dell laptop running RedHat Enterprise Linux 5.

Figure 6 Gigapan Voyage PTU, Camera, & Laptop

[1] http://gphoto.sourceforge.net/

SOFTWARE

The GV web-interface consists of five tabs: “acquire”, “stitch”, “explore”, “timelapse”, and “admin”. Via the “acquire” the user can set various capture parameters such as zoom, white balance, field of view, and overlap. The user can also specify the type of stitching they would like (i.e. fast, low quality stitching versus slow, high quality stitching). The user can immediately start another panorama capture once stitching has started. The stitch tab shows a queue of pending and executing stitch jobs. These jobs can be monitored by the user for progress and view the raw images while waiting for the stitch to complete. Once a stitch job is complete, the resulting panorama is viewable via the explore tab, similar to the gigapan.org website. Finally, the admin tab is used to start and stop the hardware.

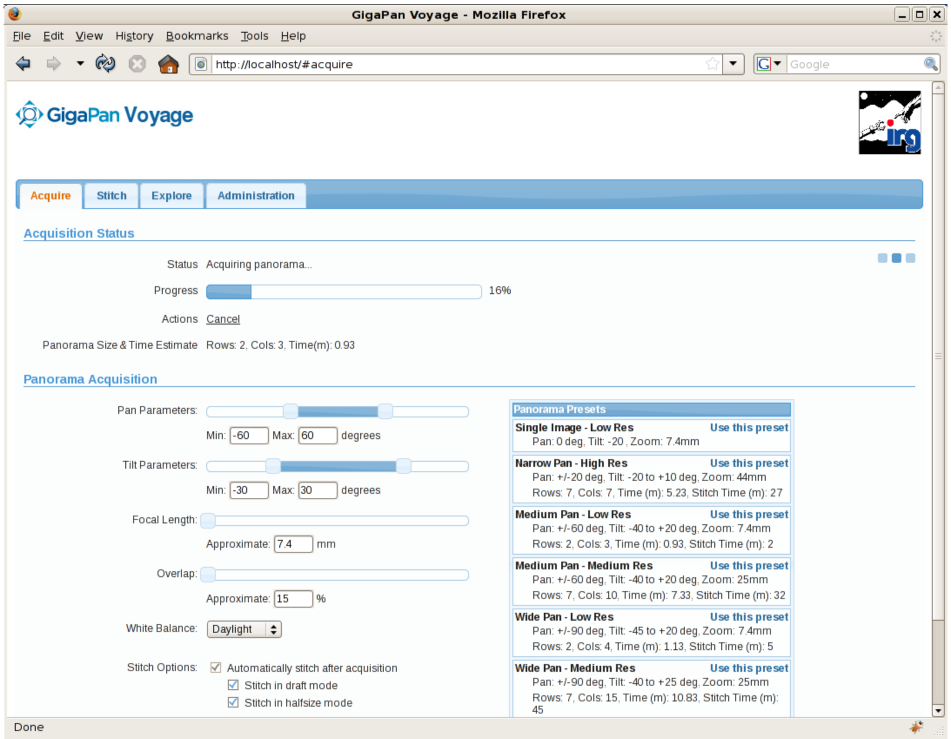

Figure 7 GV web interface

The software controlling the pan-tilt unit and camera is the same software currently being used on the K10 Lunar test rovers at NASA Ames.

Camera control including parameter setting and image download is performed using the open-source gPhoto Linux library. Coordination between the camera and pan-tilt unit is performed via in-house proprietary controller software which takes input from the web interface.

The web interface is served using the Apache web server and built using a plethora of open-source technologies including Django, mod_wsgi, SQLite, jQuery, and AJAX techniques.

The actual panorama stitching is performed using the Gigapan Stitcher[2]. Panorama exploration is available to users using the same Adobe Flash-based interface as used by gigapan.org. See appendix for the user manual and screen shots of the system.

BANDWIDTH LIMITATIONS

To better simulate a Lunar Mission and to play nice with other instruments sharing the network connection, Gigapan Voyage includes a bandwidth limiting feature. To achieve this we used the mod_bw Apache module[3] for the 2010 tests and provided the science team with the table below to help them prioritize the type of Gigapans they wanted to take.

Preset Name	Parameters	Folder size (MB)	Stitched data size (MB)	Stitched data %
Survey Panorama (2 min, 2 rows x 9 cols.)	Pan: -180.0 to 180.0 deg, Tilt: -25.0 to 20.0 deg, Zoom: 7.4 mm, Stitch Time (m) : 4	98	71	72%

[2] http://gigapansystems.com/gigapan-products/gigapan-software/gigapan-stitcher-software-information.html
[3] http://bwmod.sourceforge.net/

Survey Panorama (7 min, 3 rows x 22 cols)	Pan: -165.0 to 165.0 deg, Tilt: -15.0 to 10.0 deg, Zoom: 22.0 mm, Stitch Time (m): 7	136	80	59%
Survey Panorama (10 min, 4 rows x 24 cols)	Pan: -165.0 to 165.0 deg, Tilt: -30.0 to 10.0 deg, Zoom: 25.0 mm, Stitch Time (m): 11	188	111	59%
Med Pan - Low Res (<1 min, 2 rows, 3 cols)	Pan: -60.0 to 60.0 deg, Tilt: -40.0 to 20.0 deg, Zoom: 7.4 mm, Stitch Time (m): 1	25	19	76%
Wide Pan - Med Res (8 min, 6 rows x 13 cols)	Pan: -90.0 to 90.0 deg, Tilt: -40.0 to 25.0 deg, Zoom: 25.0 mm, Stitch Time (m): 9	168	97	58%

Table 1 Some Sample Pre-sets for 2010 Desert RATS Field Test

NEW FEATURES FOR 2010

For the 2010 DRATS field test we added the following features to better serve the scientists:

- GPS location information encoded into each Gigapan
- Archive server updated nightly to allow users in the field to view old data via faster network connection + Google map integration
- Updated Stitcher to new Gigapan.org stitcher that is about 10 xs faster than the one used in 2009.
- Updated Viewer
- Option to use the camera as a viewfinder (hidden by default due to bandwidth limitations but easily enabled)
- Easier to add new preset or edit existing ones
- Two identical units, one on each LER
- Bandwidth modulation has been incorporated into the system so that the web-server automatically limits how much data is being served. To the user, the system may seem slower when viewing raw tiles.

FUTURE WORK

Simplify Hardware Control Software

Currently the software that controls the camera and the pan-tilt unit is identical to the software running on IRG's K10 robots. This has helped speed up software development; however, it has also made the software more complex than necessary. In the upcoming year we hope to remove this dependency and be completely open-source.

Lower Cost Components

As currently designed the Gigapan Voyage system is approximately $4,000.

The cost breakdown is as follows:

$2000 for the Pan-Tilt Unit
$1500 for the Dell Laptop
$500 for the G9 Camera
$100 for miscellaneous cables, hubs, and GPS unit.

We are looking into lower cost options for each component of the system and working with Randy Sargent and the Global Connection Project to see if we could modify the Gigapan Epic Pro units to replace the Pan-Tilt Units we are currently using.

Time-lapse

Currently Gigapan Voyage contains the option to schedule and take Time-Lapse Gigapans. This tab is hidden by default but can be easily added by modifying one configuration file. The goal for 2010-2011 is to ruggedize the system so that the units could be left in remote areas for long periods of time without physical user intervention. This will also entail running the entire system off of solar power.

There are currently two proposals being reviewed by NASA to use the Gigapan Voyage system's time-lapse capabilities to study climate change. If funded this work would begin at the end of 2010.

CONCLUSION

Gigapan Voyage is facilitating connections between the rich world of Gigapan imagery to the real needs of scientists and astronauts. By expanding the realm of how Gigapans are used and integrated we hope to find new and surprising uses for the Gigapan Voyage system. In the near future we hope to give access to this system to educators and students around the world.

We would like to thank the Gigapan.org community and especially Randy Sargent for all his encouragement and guidance.

REFERENCES

Desert RATS Overview. (n.d.). Retrieved from NASA: http://www.nasa.gov/exploration/analogs/desert_rats.html

Gigapan Voyage Field Tested at 2009 "Desert Rats". (2009, October 13). Retrieved from NASA Ames: http://ti.arc.nasa.gov/news/gigapan-desert-rats-test/

APPENDIX

Gigapan Voyage User's Manual:

- ***The Acquire Tab***
  - When you navigate to the acquire tab, you will see a series of sliders and presets.
  - You can choose the settings you would like to use OR select on one of the pre-selected settings to the right. The pre-selects let you know how much time each panorama acquisition should take to help you gauge how big to set your panoramas. Also approximate stitching times are also listed although when you stitch multiple panoramas the stitching time for any individual panorama will slow down.

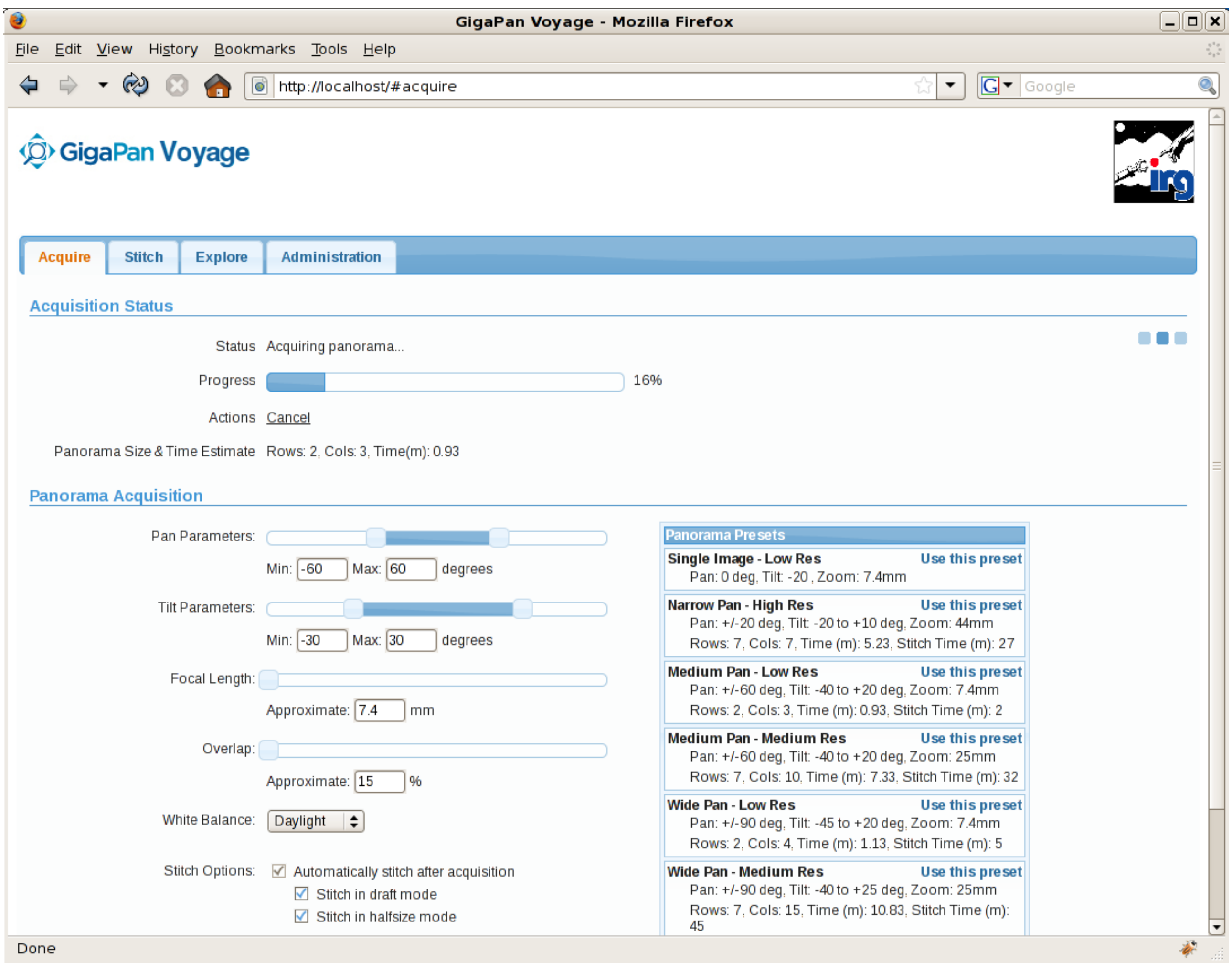

Figure 8 Acquire in progress

Settings

- Pan Parameters: the min and max angle you want the panorama to pan.
- Tilt Parameters: the min and max angle you want the panorama to tilt.

- Focal Length: the amount of "zoom" you want in your images.
- Overlap: determines how much overlap you want between images.
- White Balance: a pull down menu that allows you to set special lighting settings in the event that it's a cloudy day or a sunny day etc.
- Note: Auto white balance is not recommended since the camera will auto adjust at each image causing patchiness.
- Stitch options :
    a. If you'd like your panorama to stitch as fast as possible select both check boxes. This will save time by not blending and using half size resolution on your images.
    b. If you'd like the best panorama stitching possible, deselect the two check boxes. This will significantly increase the stitch time.
- Calculate size button:
    a. If you'd just like to know how long a panorama will take to acquire or how many images a panorama will have, you can click on the calculate size button. You will see the Status change when the new calculation is ready.
- Acquire Panorama button :
    a. Once you have decided on your settings click this button to start your panorama. There is about a 15 second start-up time during which the parameters are set on the camera after which the pan tilt head will start to move. The progress is shown on the progress bar. When complete you will see a "success" message

B. Stitch Tab

- While a stitch is in progress you may cancel the stitch. You can also resume it later if you wish.
- You can choose to delete a stitch -- this removes it from the queue. If the panorama has already completed stitching this does not remove it from the Explore tab.
- While a panorama is stitching you can view the raw tiles you took by clicking on the name of the file highlighted in red.

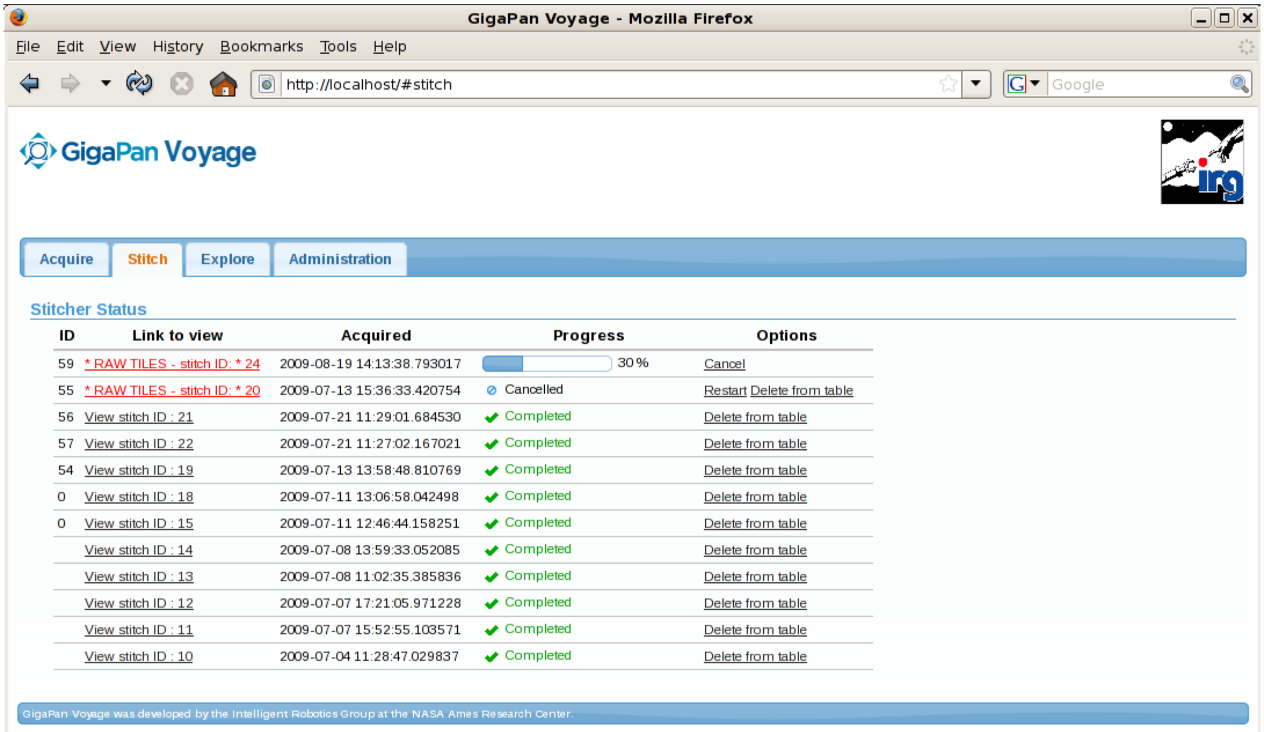

Figure 9 The Stitch tab shows the stitch job queue

C. Explore tab

- The explore tab allows the users to view the stitched panoramas using the GigaPan flash viewer.
- You can also choose to delete panoramas
- Thumbnails are generated on the fly for the newly stitched panoramas.
- If you choose to view the "raw" tiles you will also be shown the approximate pointing angle of the Pan Tilt Unit at the time the image was acquired.

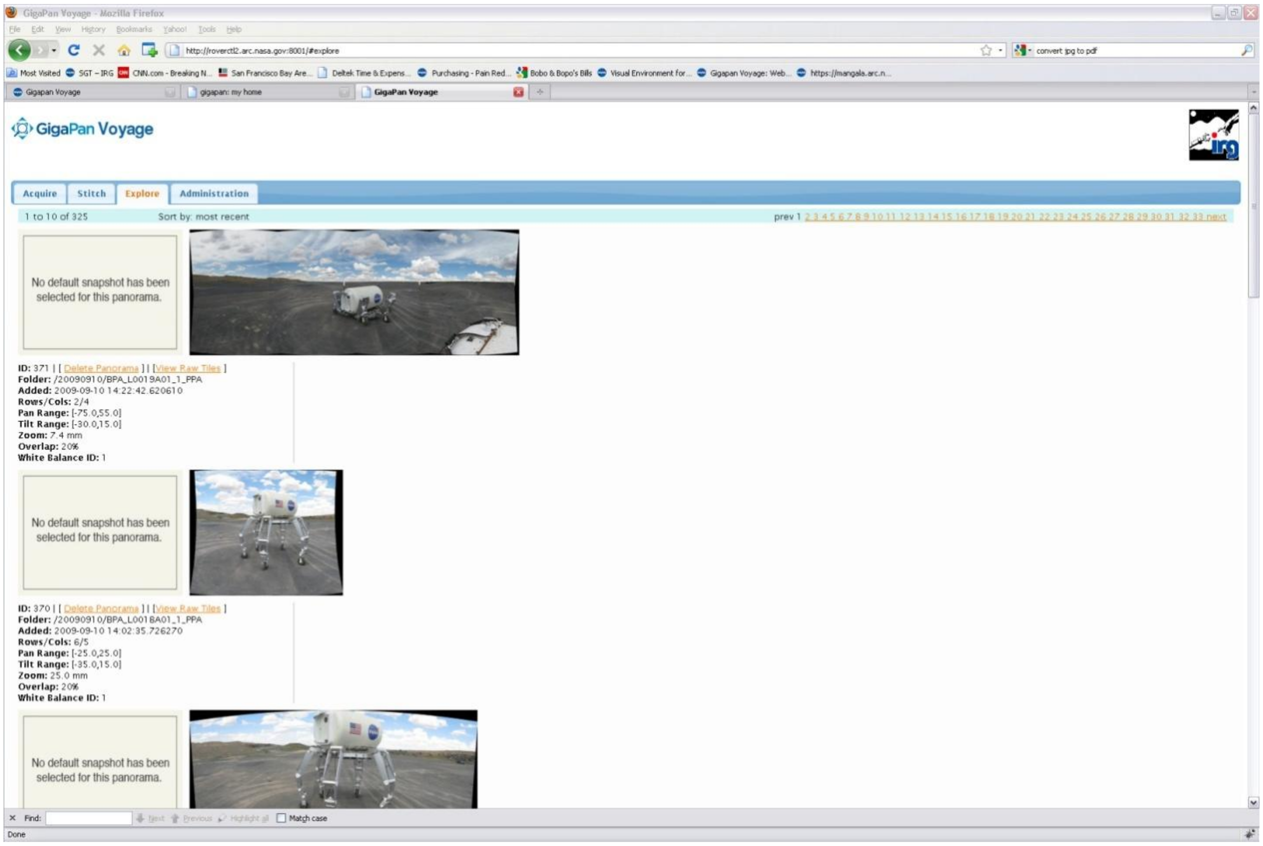

Figure 10 The Explore Tab

Snapshots

- If you select a particular panorama to explore you will be able to <Take Snapshot> and <Edit Snapshot List>
    - Zoom into a particular area of the panorama that you would like to annotate. Then click <Take Snapshot>. Type in a Snapshot Name and Description and click on <save>.
    - To edit the list you can click on <Edit Snapshot List>. You will be given the option to Update or Delete a snapshot.

D) Admin tab

- The admin tab allows the user to stop and start the controller. The controller must be running to use the acquire function of the Gigapan Voyage.

Figure 11 Admin Tab