Implementation of Machine Vision of Robotic Spacecrafts for Reducing Storage Memory and Increase of PSNR of Image

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Abstract-*Machine Vision is a technology by which a machine visualizes by using imaging devices and further human beings visualizes distant object through images captured by a machine. This paper focuses on the implementation of machine vision using MATLAB and design code to replicate the operation of a particular robotic spacecraft.*

Keywords- *Data. Image, Machine Vision, Pixel, PSNR.*

I. Introduction

Machine vision (MV) is a technology or a method used to provide imaging-based automatic inspection and analysis with a very wide scope [1,2,5,6,14]The technology defining the machine vision basically focuses on the fact that how we the humans can visualize or feel an object through machine imaging devices and sensors without touching them ourselves..

The Digital Image Processing is a technique by which we analyze process and decompose the data obtained in the form of images by the use of effective transforming principle.

The robotic spacecrafts are the unmanned spacecrafts or robots referred as rovers who move from one point to another point either on the surface or around a planet or MOON and gather information or data in the form of images through imaging devices and sensors and accomplish use of machine vision.

II. Machine Vision

Machine vision is a vast technology which defines the different ways by which humans can see and visualize the objects without visiting the places or feeling them. This technology is highly used in robotic spacecrafts which obtain information of different celestial objects by using different sensors and imaging devices. Machine vision is basically of two types:

A) Computer Vision

Computer vision (CV) is a technology by which data in the form of a image can be acquired, processed, analyzed. The CV helps in understanding data in the form of images and provide us decisions in the form of numerical or symbolic information.[7,8,9,10]

In the scientific scenario, computer vision mainly defines the ways to define systems to obtain information from images. The data in the form of images obtained from N-dimensional capturing methods basically describe the scope of CV.

B) Computer Operated Vision

This type of machine vision basically defines the same technology but in this an operator is required which will drive the system and system do not involves its in built memory. This type of vision is used in land robots were wire architecture or a human guide them to perform work.

Machine vision is based upon Graphics Processing Unit (GPU) technology. The GPU technology consists of LLNL which has fully functioning supercomputing environment. NVIDIA's Compute Unified Device Architecture (CUDA) technology is a hardware specification for its General Purpose Graphics Processing Units (GPGPUs). GPGPU's can also referred as "GPU" as GPU are Single Instruction, Multiple Thread (SIMT) devices [15, 16].

GPU computing is fundamentally different from CPU computing. GPU technology is also known as "stream processing" as it focuses on very high numbers of floating point computations. The

computer algorithm with 10x, 20x or 100x speedups even compared to a modern multi-core CPU follow this technology. GPU is five times more efficient than a CPU as GPU optimizes results and enhances CPU performance.

The Tesla M2050 and EDGE of GPU technology installed at 200 node graphics cluster, are capable of 515 double precision GFLOPS in GPU technology are capable of 1.03 TFLOPS which have double precision or 2.06 TFLOPS of single-precision which shares global memory between 448 cores or 6.25 MB per core[15]

III. Block Diagram Of Machine Vision

Machine vision basically is defined by the following block diagram:

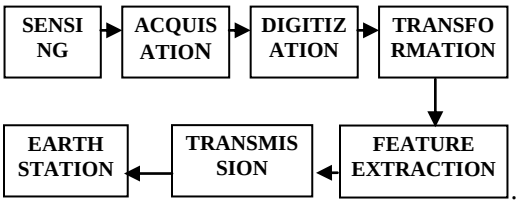

Figure 1: Block Diagram of Machine Vision

- **SENSING & ACQUISATION:** This defines how an object is sensed and acquired by the use of imaging devices like camera, scanner, etc. whose quality depends upon intensity of light of object
- **DIGITIZATION:** This defines that captured image is sampled and quantized at a defined rate following Nyquist criteria
- **TRANSFORMATION:** The transforming principle is used to analyze sampled and quantized data in different domains.
- **FEATURE EXTRACTION:** This defines the methods to extract information from data which has been captured by robotic spacecraft

IV. Computer Vision

The computer vision(CV) is building block of machine vision technology. The main reason for the development of CV field is to multiply two fold the abilities of human vision and incorporating the methods of electronic perceiving which will enhance the methods of understanding an image in complete details.[11]

The methods of understanding an image basically starts from the point of decoding the symbolic information obtained as image data and by using different models constructed by using different dimensions which includes geometry, statistics[12], Computer vision therefore is a method of representation for vision perception[3,13].The different tasks performed under CV are:

- Recognition

The basic work in computer vision is image processing, and machine vision is the way of determining the image data and specific object, or a feature. This task of obtaining of data from an image is a complex method which is done by the direct involvement of human brain and CV provides a great amount of solutions to it. The CV helps in understanding and differentiation between specific objects as simple geometric objects , human faces, printed characters and even object relative to the camera

- Motion analysis

Motion estimation is another task of CV in which an image sequence is processed and provides an estimate of the velocity of motion and thus help in analyzing each point of the image

- Scene reconstruction

In CV scene reconstruction defines a 3D model and represent an image by the use of set of 3D points. 3D imaging do not require motion or scanning algorithms but grid-based 3D sensing is used. 3D images from multiple angles are easily defined by the help of CV

- Image restoration

The aim of image restoration is the remove noise from images which may be filtered using low-pass filters or median filters. The CV technology help in distinguishing the noised image and image without noise by the use of lines or edges, and provides controlled filtering methods

V. Robotic Spacecrafts

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Robotic Spacecraft is a spacecraft with no humans on board, usually under tele robotic control which roves from one part to another on planet in the search of data collection sensed through its sensors and collects data in thee form of images which are send to earth station. These rovers employ machine vision technology and help humans to see the object without visiting the planet themselves. A CUROSITY latest robotic spacecraft sent to MARS is shown in fig 2.

It is a spacecraft with no humans on board, usually under telerobotic control. A robotic spacecraft designed to make scientific research measurements is often called a probe. Orbiting spacecraft carry a suite of instruments that might include:

• Multi-wavelength cameras for imaging the target's surface and/or atmosphere
• Temperature sensors
• A radar for topographical mapping
• A magnetometer for measuring the strength and direction of any magnetic field
• A detector for measuring particles in the solar wind

A typical rover or a robotic spacecraft comprises of following hardware components:

- Cameras
  - Dual front hazcams (hazard detection and avoidance cameras)
  - Dual rear hazcams
  - Dual navcams (navigational cameras)
  - Dual pancam (high resolution panoramic camera)
- Antennas
  - High Gain Antenna (HGA)
  - Low Gain Antenna (LGA)
  - UHF Antenna
- Solar Panels : Solar panel power generation, with Li-ion battery storage, providing 140w peak on surface
- Wheels for mobility system
- Spectrometer[16]

and structurally a robotic spacecraft or a rover contains following:

- Pancam Mast Assembly (PMA)
  - Pancam CCDs
  - Pancam optics
  - Pancam filters
- Rover Equipment Deck (RED)
- Warm Electronics Box (WEB)
- Solar Arrays
- Instrument Deployment Device (IDD)
- Rocker-Bogie Mobility System

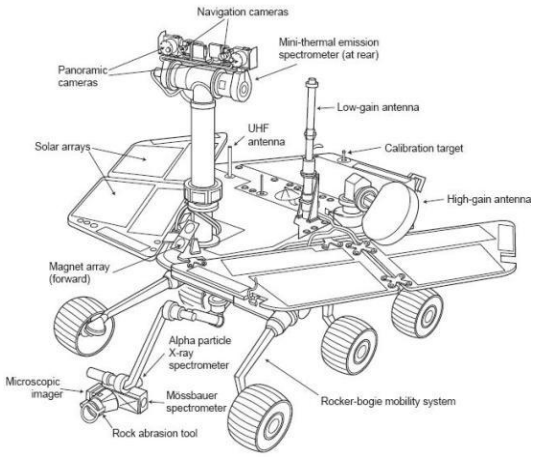


Figure 2: CUROSITY, the Robotic Spacecraft

The dimensions of a typical robotic spacecrafts are:

- Height: 1.5m / 4.9 ft
- Width: 2.3m / 7.5 ft
- Length: 1.6m / 5,2 ft
- Mass: 174 kg / 384 lb

According to Design and Verification of the MER Primary Payload, the total mass of the Mars Exploration Rover is 180.1 kg.out of which the mass of the Rover WEB is 145.6 kg, and the mass of Rover mobility components (e.g. wheels, rocker-bogie suspension) is 34.5 kg[16]

VI. Peak Signal To Noise Ratio

In a communication system data plays an important role as it is to be transmitted by the transmitter and received by the receiver end. Data can be in any form as like in the form of bits or in the form of images. The data to be transmitted is always affected by many error signals which distort it and produce errors in it. The most unwanted error is due to noise which distorts the sequence of information content in the data

PSNR is most commonly used to measure the quality of reconstruction of lossy compression codec as in image processing. The signal in this case is the original data, and the noise is the error introduced by image processing. When comparing image processing codec, PSNR is an approximation to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher Quality. [17,18]

VII. Implementation Of Machine Vision And PSNR

The implementation process is accomplished in implementing tool MATLAB R2009a .In the implementation the basic block diagram followed is as defined in fig 3.

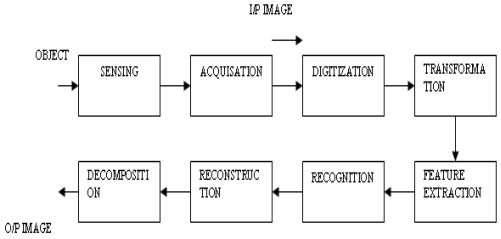


Figure 3:Block Diagram for Implementation

Implementation process is a multistep process which includes following steps:

- SENSING: In this an object is sensed and its dimensions are analyzed.
- ACQUISTION: In this object is acquired by the snapshot and image is captured.
- DIGITIZATION: In this process pixels of an image is analyzed and are digitized using sampling and quantization process.
- TRANSFORMATION: In the mage processing and principle of GPU Technology Discrete Wavelet Transform is used defined as equations 1 and 2.

$$W_{\varphi}(j_0,k)=\frac{1}{\sqrt{M}}\sum_n f(n)\varphi_{j0,k}(n) \quad (1)$$

$$W_{\Psi}(j,k)=\frac{1}{\sqrt{M}}\sum_n f(n)\psi_{j,k}(n) \quad (2)$$

- RECOGNITION: This step defines how to check the presence of required feature or not. Feature defines the requisite pixel with maximum intensity.
- RECONSTRUCTION :The image transformed using DWT is constructed using Wavelet coefficients
- DECOMPOSTION: Image is analyzed by use of different levels of decomposition and coefficients are analyzed in horizontal, vertical and diagonal directions.

The transforming principle used is wavelet transform which basically uses wavelet as HAAR/ The Haar wavelet is defined by equation 3

$$h_k(z)=h_{pq}(z)=\frac{1}{\sqrt{N}}\begin{cases}2^{p/2}\\-2^{p/2}\\0\end{cases} \quad (3)$$

$$(q-1)/2^p \le z \le (q-0.5)/2^p$$

where $(q-0.5)/2^p \le z \le q/2^p$

$$otherwise, z \in [0,1]$$

The PSNR is implemented by equation 4

$$PSNR=10\log_{10}\left(\frac{MAX_i^2}{MSE}\right)=20\log_{10}\left(\frac{MAX_i}{\sqrt{MSE}}\right) \quad (4)$$

where MSE is Mean Square Error.

VIII. Implemetation Results

In the implementation of machine vision and increase of PSNR following objective is followed:

1. To initialize the Imaging device i.e. CAMERA
2. To acquire and obtain multiple snapshots of an object
3. Selection of best snapshot and its conversion into grayscale
4. Applying DWT to calculate wavelet coefficients
5. Image Compression as image processing is done
6. Reconstruction of images at two levels
7. PSNR is calculated for both input snapshot and processed image and difference is determined to determine the net increase in PSNR

The implementation results for every objectrve is as follows:

1. Initialization (includes sensing and acquisition)

Figure 4:Sensing and Acquisition

2. Multiple snapshot (termed as MOSAIC IMAGES)

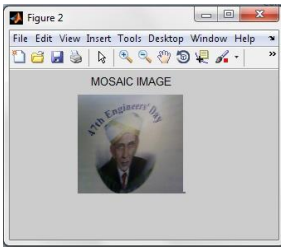
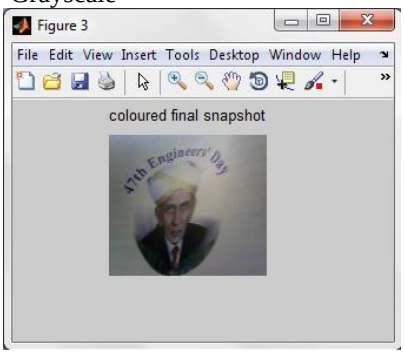
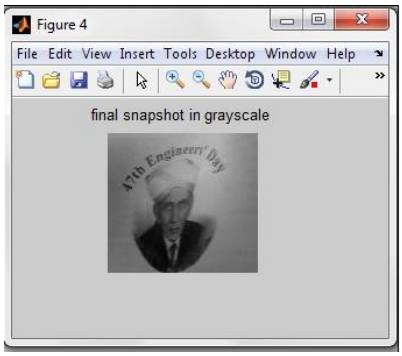


Figure 5:Mosaic Image

3. Selection and snapshot conversion into Grayscale



{A}



(B)

Figure 6(A):Final Selected Snapshot
6(B):Snapshot in Grayscale

4. Image processing and compression
5. Multiple level reconstruction

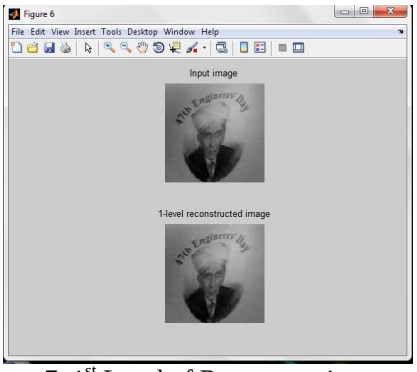


Figure 7: 1st Level of Reconstruction

6. PSNR graphical analysis

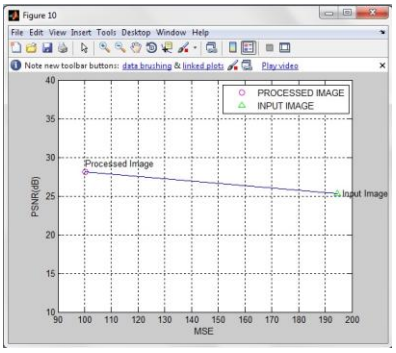


Figure 8:PSNR v's MSE Graph for Both Processed and Input Images

7. Final Output

```
      Filename: 'manas.jpg'
   FileModDate: '20-Sep-2014 13:18:08'
      FileSize: 2741
        Format: 'jpg'
 FormatVersion: ''
         Width: 160
        Height: 120
      BitDepth: 24
     ColorType: 'truecolor'
FormatSignature: ''
NumberOfSamples: 3
  CodingMethod: 'Huffman'
 CodingProcess: 'Sequential'
       Comment: {}
```

```
          Filename: 'compressed.jpg'
       FileModDate: '17-Sep-2014 00:59:10'
          FileSize: 2678
            Format: 'jpg'
     FormatVersion: ''
             Width: 120
            Height: 120
          BitDepth: 8
         ColorType: 'grayscale'
   FormatSignature: ''
   NumberOfSamples: 1
      CodingMethod: 'Huffman'
     CodingProcess: 'Sequential'
           Comment: {}

PSNR of input image
   25.2728

Mean Square Error of input image
  194.6234

PSNR of processed image
   28.1509

Mean Square Error of processed image
  100.3202
```

Figure 9:Final output data

IX. CONCLUSION

The implementation of machine vision in implementing tool MATLAB defines a new way of image processing on the basis of real time and through it real time image processing isaccomplished.The PSNR increase also defines that level of noise has been reduced.

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REFERENCES

Journals

[1] Graves, Mark & Bruce G. Batchelor (2003). *Machine Vision for the Inspection of Natural Products. Springer. p. 5.ISBN 978-1-85233-525-0. Retrieved 2010-11-02.*

[2] Holton, W. Conard (October 2010). "By Any Other Name". Vision Systems Design 15 (10). ISSN 1089-3709. Retrieved 2013-03-05.

[3] Barghout, Lauren, and Jacob Sheynin. "*Real-world scene perception and perceptual organization: Lessons from Computer Vision." Journal of Vision 13.9 (2013): 709-709*

[4] Huynh-Thu, Q.; Ghanbari, M. *"Scope of validity of PSNR in image/video quality assessment". Electronics Letters 44 (13): 800,2008*

Proceedings Papers

[5] Steger, Carsten, Markus Ulrich, and Christian Wiedemann (2008). *Machine Vision Algorithms and Applications*. Weinheim:Wiley-VCH. p. 1. ISBN 978-3-527-40734-7. Retrieved 2010-11-05

[6] Relf, Christopher G. (2004). *Image Acquisition and Processing with LabVIEW* 1. CRC Press. ISBN 978-0-8493-1480-3. Retrieved 2010-11-02

[7] Reinhard Klette (2014). *Concise Computer Vision*. Springer. ISBN 978-1-4471-6320-6.

[8] Linda G. Shapiro and George C. Stockman (2001). *Computer Vision*. Prentice Hall. ISBN 0-13-030796-3

[9] Tim Morris (2004). *Computer Vision and Image Processing*. Palgrave Macmillan. ISBN 0-333-99451-5.

[10] Bernd Jähne and Horst Haußecker (2000). *Computer Vision and Applications, A Guide for Students and Practitioners*. Academic Press. ISBN 0-13-085198-1.

[11] Milan Sonka, Vaclav Hlavac and Roger Boyle (2008). *Image Processing, Analysis, and Machine Vision*. Thomson. ISBN 0-495-08252-X.

[12] David A. Forsyth and Jean Ponce (2003). *Computer Vision, A Modern Approach*. Prentice Hall. ISBN 0-13-085198-1.

[13] Dana H. Ballard and Christopher M. Brown (1982). *Computer Vision*. Prentice Hall. ISBN 0-13-165316-4.

Website Links

[14] http://en.wikipedia.org/wiki/Machine_vision

[15] https://computingllnl.gov/vis/gputechnology.shtml

[16] http://bionews-tx.com/news/2013/03/27/baylor-college-of-medicine-and-rice-university-genomics-researcher-delivers-keynote-address-at-nvidia-gpu-technology-conference/

[17] http://mars.nasa.gov/mer/home/index.html

[18] http://web.mit.edu/xiphmont/Public/theora/demo7.html

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