Origami Inspired Rovers To Boost Mars Explanation

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Abstract - — Origami robots have unique characteristic property to re-configure themselves and serve for multiple purpose during their use. Such potential in new generation rovers can be favourable for a wide variety of applications including research in Space technology. They can be the intelligent assistants for the astronauts, even adapt themselves into unique environment of space and explore rough terrains. Self assembly from 2D shapes to 3D structures after the landing makes them special, even reduces the payload and area to carry. Being artificially intelligent they no more require any human interference or help in any working conditions.

Keywords*:Origami rover, Space science.*

I. INTRODUCTION

The traditional rovers or the classical rovers are being constructed and functions based on the number of fixed joints and actuators. This proves that their performance and shapes are already defined. So even though they have a very good functionality and results,they can only serve for what they are designed for. Even compared to orbiters, there are the higher chance of failure, due to landing and other risks, and that they are limited to a small area around a landing site which itself is only approximately anticipated. So these are some of the major drawbacks in the world of space science and robotics technology. To overcome this drawback a new vision of generation of rovers are introduced which function, all depending on erratic environmental conditions and intelligence.

Origami is a convenient and versatile platform for developers. From single sheet of paper, multiple shapes can be made. Using any 2-D surfaces, 3-D forms can be designed and this theory is proven mathematically. Assume an intelligent sheet with a simple polygonal shape and using that shape, we can recreate multiple variety of 3-D forms that rebuilt according to the erratic environmental conditions and workload. If you were to have an intelligent sheet that can self fold into any form anytime it wants, we call this technology as Robotic Origami or Robogami.

Robotic origami are re-configurable two-dimensional (2-D) crease patterned robots that can re-built various three-dimensional shapes with infinite degree of freedom (DoF). Low-profile body parts and components of origami robots are processed in 2-D, followed by robotic assembly in 3-D.

Robogami neither has any fixed shape nor anyfixed task to perform. They can rebuiltthemselves into anything. The most challenging part for the design of Robogami is to keep them super thin, angular and still act functional. So these type of rovers are quite important for the difficult and unique environmental conditions on the Earth and in space.Specially talking about the space, it is the perfect environment for the Robogami as one cannot afford to have one robot for single task. The Robogami not just used for the exploration but also can be proved as an additional help for the astronauts. They need to do every task, may be tedious or interesting and be super interactive as well. So what we need is these multifunctional robots to carry out their experiments, assisting them with the communication and just docking onto the surfaces to be their third arm holding different tools.

A. Goals or Objectives:

- To overcome the physical and technical challenges faced by traditional rovers.

- To decrease the payloads and area covered inside the rocket by the rovers.

- To explore unexplored terrains from mars and other space colonies.

-To design it artificially intelligent so as to reduce human interference and problems during communication and research.

- To increase the area covered by these rovers for advanced exploration and research.

-To experience the real time conditions of mars using VR technology.

II. LITERATURE SURVEY

"Design methodology for constructing origami robots and machines" ZhenishbekZhakypov published in February 18. The guidelines for what framework should be used was referred from this paper. This paper discuss a systematic design methodology for building origami-inspired machines and robots using four major features: Mechanism, fabrication, geometry and

characterization.Throughout the document, decisions that must be made while you design are identified**. [1]**

"Game Changing Development A-PUFFER: Autonomous Pop-Up Flat-Folding Explorer Robots" published by National Aeronautics and Space Administration. The aim of this paper is to use origami technology to explore mars and other space colonies. In this paper design methodology for rover companions known as PUFFERs are proposed. It aims to advance the technologies used in traditional rovers. Also can act as intelligent companions for the parent rovers. Even explore promising locations. **[2]**

"A method for building self-folding machines" S. Felton published in March 16. The aim of this paper is to develop self folding machines. They developed shape-memory composites that fold themselves along embedded hinges. This design is much useful for the building actuators and joints. Also provides the design and analysis of conversion of 2D planes to 3D surfaces. .To demonstrate the application of these techniques to the fabrication of machines, tripod robot that folds itself was developed.The robot starts as a flat sheet with embedded electronics, and transforms autonomously into a functional machine **[3]**

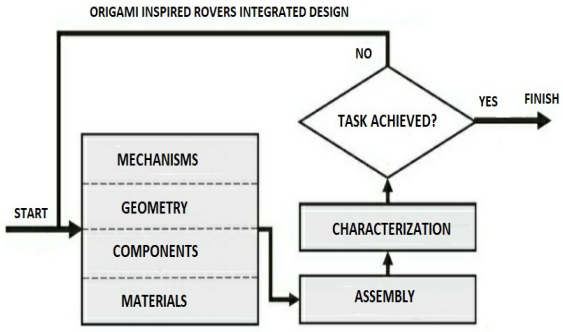
III. PROPOSED WORK

The intent of our paper is to provide design methodology for construction of Origami rovers. These rovers are basically designed in 2D forms and then assembled into 3D shapes which reduces the payloads and area covered. These rovers are the upgraded or modern versions of traditional rovers. They can easily explore mars and other space colonies with promising locations and harsh terrains. Also they shall work on self intelligence hence no human interference is required. The design of rover is such a way that it can select the area for research, travel longer distance through quad-copters and make precise decisions . Scientist would be able to experience real time conditions over mars using VR technology. These new vision of generation of rovers functions all depending on erratic environmental conditions and intelligence. The new design if rovers protects itself from obstacles and stiff slopes through air bags which may increase their durability,free from maintenance and able to repair themselves.

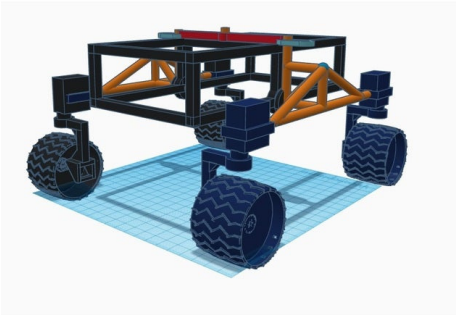
IV. DESIGN METHODOLOGY

Material selection for rover

The Origami based rover project is developing autonomy for a novel origami-inspired, ultra-compact rover technology to expand the scientific reach of future space missions.Exploring Mars and other space colonies might be much productive and easier using Origami based light weightrovers. This robot is capable of flattening itself out, squeezing into tight spots and clambering up rough terrains.These rovers could eventually explore promising locations and explore places that are off-limits.The main body is constructed of aluminium and composite fiber reinforced plastic sandwich material. The material is designed such a way that it can resist highand low temperatures, pressure, dust, corrosion, cosmic rays. The geometrical shapes of the rover is designed in 2-D crease patterns and multilayers. These 2-D crease patterns and multilayers folds in a sequence, with respect to folding angles and Cartesian position into 3D body with infinite degree of freedom. The material undergoes bending, torsion, lateral bending, shear, compression and elongation. Also the material must satisfy the properties like nonlinear fold elasticity and deformation, smooth fold dynamics, high-dimensional fold space. The 2-D parts of the rover are manufactured using CNC and laser micro-machining technology, multi-material 3-D printing, 3-D deposition, molding, layer-by-layer lamination, pressing, heat treatment, forming and stamping. Hence after the manufacturing of the parts, the components undergoes assembly.



[Fig.(A) Integrated design of origami inspired rover. Origami inspired rovers are re-configurable two-dimensional (2-D) crease patterned rovers that can re-built various three-dimensional shapes with infinite degree of freedom (DoF). Low-profile body parts and components of origami robots are processed in 2-D, followed by robotic assembly in 3-D]



[Chassis of the mars rover]

A commonly used design element in most of the rovers over the years is the rocker bogie mechanism. The rocker bogie mechanism has quite a lot of advantages and is hence a well-established mechanism. The main advantage is that it ensures that all the wheels of the rover are in contact with ground all the time. This flat folding rover majorly consist of four wheels and one metallic tail which folds according to the erratic environmental path and rough terrains. It's designed to crawl slowly up to 45-degree slopes, investigate overhangs, pits and craters. The basic application of tail is to support the body while crawling upwards and downwards.

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ROVER ELECTRONICS

The electronic system includes the power system, robotic arm system, driver system, video transmission and reception system, radio frequency communication system, navigation system, sensors system and camera system.

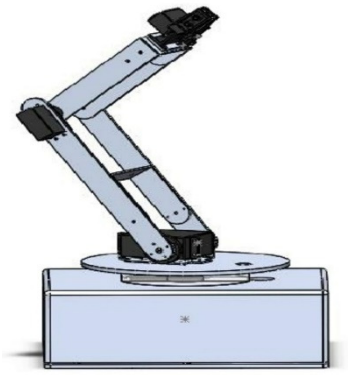
A. POWER SYSTEM

- Battery: The system uses 16Ah 22.2V Lithium Polymer batteries that are very lightweight, has reasonable current capacity, reliable and rechargeable using solar panels.

- Battery Monitoring System: Battery monitoring system is built to have a check on battery and current capacity. The solar panel is attached at the belly of rover which flips upside down during low battery indications by the system.

B. ROBOTICARM

The inverse kinematic robotic arm has 3-links and 8 degrees of freedom. Because of its rotational capability, the 3 degree of freedom base has maximum reachability around the rover, irrespective of the rover orientation. The arm is equipped with a gripper turret with 3 types of end effector. One of them is a two link gripper mechanism. The second is a four link gripper mechanism for circular gripping and opening valves. The third end effector is an Archimedes screw that can be used for soil collection. The arm body as a whole has 2 additional degrees of freedom



[Robotic arm with 3 links and 8 degrees of freedom]

for linear movement across the rover body along a platform on a belt driven linear actuator. In addition, the linear actuator and arm can rotate on a DC stepper motor, fixed at the rover base to rotate the arm by 360 degrees on a horizontal platform. The robotic arm is capable of repairing its own rover electronics even it has a camera working on Artificial intelligence which detects perfect samples for experimenting and areas of research.

C. DRIVE SYSTEM

- Motors: We use 18V brushed DC planetary gear motors, with gearing ratio 1:256 and 76 RPM, with Stall Torque of 300.8 kg-cm.

- Steering Actuators: Our Rover Design uses high torque 30 RPM brushed DC gear motors as steering actuators, with shaft encoders, for making it faster and reliable actuators.

- Motor Driver: We use a 120A motor driver, suitable for high powered robots. The driver allows us to control the motors with: analog voltage, radio controls, serial and packetized serial. Overcurrent and thermal protection are included in driver itself.

- Quad-copter: The quad copter drives the rover to desired location through GPS mapping which may not restrict the location under research,In order to investigate narrow, deep and risky areas.

D. VIDEO SYSTEM

- Main Camera: We use a pan and tilt Night Vision CCTV wireless camera with 1 km range.

- Arm Camera: We use a camera with 5.8 GHz AV receiver. This camera provides a decent vantage point of the arm end effector and the arm objective. This allows for precision in locating and orienting the end effector to perform various equipment servicing tasks such as opening valves, operating switches, etc.

MAIN CONTROL SYSTEM

We use INTEL-NUC processor and microcontrollers for controlling each subsystem. Image processing is done by Intel NUC. Other subsystems are controlled by Arduino Mega microcontrollers.

E. COMMUNICATION SYSTEM

- Control Radio: We use 2.4 GHz Radio Frequency 9-channel Transmitter to control the rover. We use 2.4GHz XBeeXBP24-AWI-001, for controlling therobotic arm.

- Video Transmission: Main camera is a wireless camera with 2W transmission power and operating frequency of 2414-2468 MHz. The camera on the robotic arm has a transmitter frequency of 5645-5945MHz with 500mW power output.

- At Base Station: We have 2.4GHz 9 channel transmitter, 5.8GHz 32 channel AV Receiver and 2.4 GHz AV receiver, 2.4 GHz XBee Transceiver to receive sensor data and send control signals.

F. NAVIGATION SYSTEM

Connected to an external antenna on the rover main control board, the Garmin GPS-15x receiver (with WAAS capability) is used to navigate and localize itself. This module provides functionality of abstracted navigation and is connected directly to the microcontroller, for parsing the NMEA navigation strings.

G. SENSORS

We use the below mentioned sensors for analyzing the following conditions:

- Moisture Sensor: For identifying the water content in the soil sample, we use a soil moisture meter
- Temperature, pressure and humidity Sensor
- PH Sensor: To determine the PH of the soil sample using four buffer solutions
- Distance Measurement
- Air Quality Sensor: To determine the contents and quality of air at a location
- Light Sensor: For determining the light intensity at the given location
- Inertial Measurement Unit
- Digital Compass: To increase the accuracy of localization and terrain traversing

ADDITIONALFEATURES

A. STEREO VISION AUTONOMOUS NAVIGATION SYSTEM

The rover is equipped with autonomous navigation unit that can help in reaching required destinations without the help of manual instructions. The heart of the system is Intel NUC Celeron processor, and main input sensors are stereo vision cameras and ultrasonic transducers. Stereo vision is based on Simultaneous Localization and Mapping (SLAM) algorithm to perform intelligent navigation. The SLAM unit takes the GPS coordinates of the destination as input and plans the shortest path from the current location. As it traverses along
the planned path, the rover will generate the three-dimensional map of the environment and localize itself in the developed map.

B. AIRBAGS SYSTEM

An airbag is a rover restraint system using a bag designed to inflate extremely quickly, then quickly deflate during collision. It consists of the airbag cushion, a flexible fabric bag, an inflation module, and an impact sensor. The purpose of the airbag is to provide a rover a soft cushioning and restraint during a crash event. Whenever the rover falls or collides to the surface, immediately the sensors gets activated which makes the airbags open. The airbags immediately gets filled with nitrogen gas and protects the vehicle from getting damaged.

V. CONCLUSION

This rover technology overcome the physical and technical challenges faced by traditional rovers. The rover uses sustainable and rechargeable Li polymer battery. The folding technology has decreased the payloads and area covered inside the rocket by the rovers. The rovers can even explore unexplored terrains from mars and other space colonies using the tail and wheel folding technology and quad-copter present in the rover. It is artificially intelligent so as to reduce human interference and problems during communication and research. The rover can fix any technical or connection problem inside the rover using

robotic arm. The rovers are much durable with durable communication technology. Even the rover can select the type of component to study. The rover even broadcasts the live experience the real time conditions of mars using VR technology. This folding technology of the rovers acts according to rough terrains and surroundings. The rovers have airbag technology which protects them from getting damaged.

VI. REFERENCES

[1] ZhenishbekZhakypovand Jamie Paik, "Design Methodology for Constructing MultimaterialOrigami Robots and Machines",IEEE TRANSACTIONS ON ROBOTICS, VOL. 34, NO. 1, FEBRUARY2018

[2] "Game Changing Development A-PUFFER: Autonomous Pop-Up Flat-Folding Explorer Robots" published by National Aeronautics and Space Administration.

[3] S. Felton, M. Tolley, E. Demaine, D. Rus, R. Wood, "A method for building self-folding machines", 8 AUGUST 2014 • VOL 345 ISSUE 6197

[4] https://www.ted.com/talks/jamie_paik_origami_robots_that_reshape_and_transform_themselves

[5] A method for building self-folding machines S. Felton ,M. Tolley, E. Demaine, D. Rus, R. Wood published in March2016.'

[6] Design and Development of an Intelligent Rover for Mars ExplorationAswath S, Unnikrishnan VJ, Sreekuttan T Kalathil, Abin Simon, Hariprasad CM, Deepu P Mathew, Maya Menon, Praveen Basil, Ragesh Ramachandran, Abhay Sengar, Arjun Balakrishnan, Kailash Dutt, Arun Murali, Chinmaya Krishna Tilak, Amal Suresh, Adithye Suresh, Balakrishnan Shankar and Ganesha Udupa

[7] An Origami-Inspired Reconfigurable Suction Gripper for Picking Objects With Variable Shape and Size ZhenishbekZhakypov , Florian Heremans , Aude Billard , and Jamie Paik published at IEEE ROBOTICS AND AUTOMATION LETTERS, VOL. 3, NO. 4, OCTOBER 2018

[8] Assembled Additive Manufacturing – A Hybrid Fabrication Process Inspired by Origami Design

[9] Dongping Deng Yong Chen* Daniel J. Epstein Department of Industrial and Systems Engineering University of Southern California, Los Angeles, CA 90089, U.S.A.

[10] " Robogami: A Fully Integrated Low-Profile Robotic Origami"AmirFirouzeh and Jamie Paik