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# Space Exploration Using the Internet of Things

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## Introduction

The Internet of things (IoT) has found wide applications in many areas such as healthcare, smart homes and buildings, smart cities, retail, energy, manufacturing, mobility and transportation, and logistics. However, IoT technologies have not yet been applied to space research.

The overall goal of this project is to develop and implement a test-bed where we can experiment on the applications of the IoT framework and technologies to research on space exploration. Specifically, an IoT prototype is implemented to facilitate the procedure of sensing, processing, and responding to useful data from remote planets. This prototype in the test-bed is built using a Raspberry Pi microcontroller, a pi-camera, and a moving robot. The movement of the robot can be controlled remotely through a web framework. That is, a user is able to send movement commands to the robot through a web browser. Meanwhile, the real-time video from the pi-camera is shown inside the browser. Such a prototype simulates space exploration by using sensors to detect useful data (e.g., visual terrain information) and control the movements of robots on the planet (e.g., Mars) in the test-bed.

This research also helps us better understand the limitations of IoT technologies in space exploration. The limitations include, but are not limited to, camera quality, live-stream speed, and the processing speed of the Raspberry Pi controller.

## Future Work

The future work of this project is to enhance the test-bed by adding more sensors such as distance and motion sensors. Moreover, techniques will be investigated to improve the streaming quality of live video across different networks. Finally, the security of the test-bed has not yet been assessed. Therefore, methods will be studied to make the system more secure.

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## Current Challenges and Possible Solutions

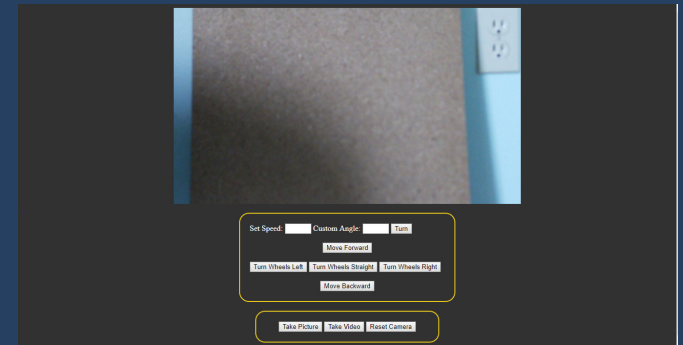
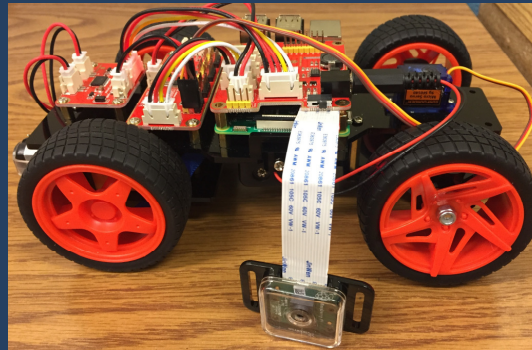
In IoT, current popular protocols on data transmission across different networks do not support streaming video well. Protocols such as MQTT, which is used to stream data, do not support the transmission of video data. Other protocols like CoAP are not reliable streaming protocols, and data can be lost using them. One possible solution to such a problem is to assign a public IP address to the Raspberry Pi streaming the video.

Moreover, YouTube can be used to stream video and be accessed remotely. As a result, the live stream is sent by the Raspberry Pi to a live link on YouTube in real-time.

## Contribution

The contribution of this research is a basic prototype of an IoT-based system with off-the-shelf components for space exploration. Overall, this project provides a better understanding of space research.

## Test Bed



## Design Components

The robot is controlled by a Raspberry Pi 3 Model B. A user can set the robot's speed and turning angle. A user can move the robot by clicking a button (e.g. "Move Forward") on the web page. Clicking the button sends a request to the Raspberry Pi that then interfaces with the various motors (e.g. back DC motors) on the robot to carry out the user's request. Moreover, a pi-camera is attached to the Raspberry Pi that streams video to a web browser. Specifically, the video uses a Motion JPEG streamer. Users can take pictures or videos and email them to themselves.