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INTEGRATING SAM SENSORS WITH ROVER SIMULATORS FOR ENHANCED EXPLORATION MISSIONS

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ABSTRACT: Most of the time, it is faster and easier to show a complicated automaton through a computer simulation that combines hardware and software than through normal physical copies that need to be stretched or shrunk. For our study, we will use the computer next to us to make a model of the Mars Rover. The Rover and the Mission Control and Command Center are the two main parts of it. The Rover and Mission Control can talk to each other using the same communications device. Simulations that keep track of research and progress make it possible to find bugs. A few of the many tools that come with the program are radiation detectors, APXs, spectrometers, radios, and REMS. A service layer is also used to receive data for several rover devices. This paper gives a thorough look at how the SAM (Sample Analysis on Mars) set of tools were used in the Mars Rover exercise.

KEYWORDS: Curiosity; N.A.S.A.; Sample Analysis on Mars; Java; Simulation

1.INTRODUCTION

Modeled after the NASA Mars Rover "Curiosity," this project aims to replicate its features. Basically, it's a research instrument for the MSL Science Mission. The simulation faithfully mimics the operation of the various sensors on the "Curiosity" rover throughout the calibrated mission window. Additionally, it attempts to model the operation of most sensors by retrieving data from NASA's online sensor data archives and providing real-time output with it.

These outcomes demonstrate that the project serves as an excellent educational resource. Its ability to incorporate engineering data from the MSL in many ways makes it a versatile diagnostic tool; for example, it can display the operational status of the MSL's numerous sensors.

Learning about the rover is a breeze with the model's graphical user interface (GUI). The Mars Rover emulator is compatible with any computer system that supports a Java virtual machine (JVM) because it is built in Java. This makes it portable. Furthermore, the game can serve as a cooperative tool to facilitate collaboration amongst specialists in several interdisciplinary domains. Furthermore, the project incorporates a system for accurately and efficiently documenting errors.

2.LITERATURE REVIEW

Mars Rover

When the Mars rover arrives at the red planet, it will begin to move across the surface. The range of a stationary lander is less than that of a mobile rover. Some intriguing things they could do include finding a sunny spot to spend the winter or making significant strides in the area of remote autonomous vehicle management.

Curiosity

The Mars Science Laboratory (MSL) initiative is a component of it. In terms of size, the rover Curiosity is close to that of a vehicle. Examining Mars's Gale crater is the objective of the mission. Studying Mars' climate and geology, determining if the Gale field location has ever been an ideal environment for microbes to live (including investigating the role of water), and studying the possibility of Mars as a livable planet are all part of the rover's preparations for human exploration. The arrival of Curiosity on Mars occurred on August 6, 2012. After 2323 sols, or 2386 Earth days, on February 17, 2019, it was considered over. The rover appears to be operational. The Curiosity serves as the structural basis for the 2020 Mars Rover.

The initial step in the comprehensive sample analysis process is to use high-resolution cameras to identify out-of-the-ordinary features. By vaporizing a little section of the surface of interest and analyzing the ensuing spectral trail, Curiosity can determine the elements in a rock. If the rover is interested in studying that signature more thoroughly, it can use its extended arm to grasp an X-ray spectrometer and a microscope. Additional testing can be conducted by sending a powdered sample from the rock sample sent by Curiosity's onboard analytical labs to the CheMin Institute of Technology in Navi Mumbai, India. For the most part, the

One for the Mars Hand Lens Imager (MAHLI) (1), one for the Mars Descent Imager (MARDI) (1), one for the Chemistry and Camera (ChemCam) (1), one for the Navigation Camera (NavCams) and one for each of the Mast Camera (MastCams) and the Hazard Avoidance Camera (HazCams) are among the seventeen additional cameras on the rover.

Instrument suites comprise a number of devices, one of which is the Rover Environmental Monitoring Station (REMS). It surveys its Martian environment.

light, air pressure, humidity, wind speed, and ultraviolet radiation . To analyze gases and organics from changes in pressure, temperature, and the atmosphere, we have the SAM instrument suite, the CheMin instrument for X-ray powder diffractography and fluorescence, and the APXS instrument for mapping the spectra of re-emitted X-rays to determine the elements in samples .

Sample Analysis on Mars (SAM)

Scientists can learn more about the chemical composition of Mars' atmosphere and surface in Gale Crater with the help of Sample Analysis at Mars (SAM), a suite of three powerful technologies carried by the Mars Science Laboratory (MSL) Curiosity rover. Scientists will be able to determine if Mars has ever had or has evidence of microbes using SAM's data. With this new information, we can see how the environment has evolved throughout time.

The SAM sensors were downsized from their original size, which might have fit in an Earth lab, to fit within the Curiosity rover, which is about the size of a microwave oven.

A gas chromatograph (GC), a quadrupole mass spectrometer (QMS), and a tunable laser spectrometer (TLS) are all part of the SAM experimental set. Devices for processing and handling samples are also included.

Gases collected from the air and regolith or heated or chemically treated pulverized rock samples will both be examined by SAM. The search for and study of inorganic and organic molecules crucial to Earth's habitability will be the focus of SAM. Data on the Martian chemistry, both ancient and modern, will also be gathered by it.

3.EXISTING SYSTEM

Kernel

When it comes to the Mars rover, the kernel is where it's at. Both the basic and complex operations of the rover are handled by it. All operations, including state changes, performed by the rover, including construction of the state machine, are handled by the kernel.

Consequently, it is responsible for monitoring the Mars robot's operations. The component's functionalities are connected by it. At startup, the kernel performs the bootstrapping procedure, more commonly known as "initialization" in our setting. The sequence continues with a check of the rover's battery and each monitor's status. Using the spacecraft's position monitor and clock, our kernel—a basic state machine—operates.

Spacecraft Clock

The timer regulates the Martian rover's operational duration, making it a crucial component. The rover's durability degrades with each use. This is monitored by the spaceship's watch. Time scale factor, current UTC time, sol, and mission end time are among the main pieces of information provided.

The 20-minute lag in real-time communication can be compensated for by adjusting the period factor. The data recordings of the rover can be accessed using the space clock. All devices are calibrated by use of the spaceship clock.

Daemon Processes

Daemon processes allow the Mars Rover to execute background tasks independently of other processes that require specific resources or operating power. In order to determine which programs require kernel updates on a regular basis, daemon processes play a crucial role for the Mars Rover.

A wide variety of server processes are utilized by the Mars rover, including

- Pacemaker
- Garbage Collector
- Battery Monitor
- Sleep Monitor

Pacemaker

You can think of the pacemaker as the "Heartbeat" of the Mars rover; it also sets up all the critical data, including Sol, module reporting, rover configuration, and battery level. Yes, in addition to the page. By routinely activating and monitoring critical operations, the pacemaker maintains a constant heart beat.

Garbage Collector

The purpose of Garbage Collector is to ensure that the rover does not get an excessive number of requests, particularly when it is asleep or hibernating, by keeping the command queue filled.

The Garbage Collector queue monitor constructs the Runnable interface using multithreading. The rover will purge the deleted commands and record the total number of deleted commands when the instruction queue becomes too full while it waits. Even if there are people waiting in line while the rover is asleep, everything still works according to plan. As an additional responsibility, this function processes distress signals, clearing the instruction queue and initiating the stop procedure as soon as it receives one.

Battery Monitor

For risk-free process execution, the battery monitor displays the current condition and monitors the battery level. Using the battery monitor, we want to determine whether the rover's present battery level is sufficient to keep it operational or if additional charging is required. When the rover's battery becomes low, it will also notify you. For faster processing, the Mars Simulator's battery monitor makes use of multithreading.

Before acting on instructions, it enters the Listening State to verify that there is sufficient power from the main and auxiliary power units. When the battery life is getting low, it enters the Recharge-State and notifies the kernel. The instruction queue is used to hold commands during this process. When the battery level reaches the alert level, the rover is turned off by an interrupt. The execution of instruction queue requests occurs during the bootup process, which begins once the device is charged. The rover enters a sleep mode rather than turning off entirely when the power remains low and the alarm level is not satisfied. The battery monitor follows a predetermined schedule to conduct routine surveillance. At each interval, the public is informed of the rover's present status and the outcomes of the inspection.

Sleep Monitor

You can see the rover's status on the sleep monitor. When it goes into sleep mode, the rover lets you know it's ready to resume normal operations. The routines first verify the sleep state against the provided state to ensure the orders are valid.

The sleep watch's function is to initiate the sleeping and waking processes. Additional means of controlling the sleep steps include a runnable interface and numerous threads. When the quantity is reached, the rover will enter sleep mode. After that, you may see the time the message was sent and received on the screen.

The robot will go to sleep when it detects no change. A user can configure the rover's snooze time to determine how long it will sleep. The rover is automatically awakened whenever the watch determines that it is time for it to sleep. The sleep tracker is instructed on when and how to work by means of a plan.

4.SAM IMPLEMENTATION & RESULTS

By streamlining and simplifying the graphical user interface, the developers aimed to increase the number of scientists who could access MSL data. A writing field and button representations of the sensors are provided.

Animation Engine

The simulation's animation engine follows the design principles of the Java Swing user interface. Every sensor has its own animation engine. The associated sensor's animation engine kicks in as soon as the kernel reaches that condition. The current location of the rover can be seen in the two-dimensional image as a dot. The animation engine is then manufactured according to a factory-based design. It gives the signal to the animation company to begin their work. What keeps it together is its pivot engine. The animation adds visual information to the data exchange by sending a flashing dot to the SAM sensor.

Protocol Buffers

A versatile method for serializing structured data that is compatible with any device or language, the protocol buffer was developed by Google. When compared to this, XML and JSON, two other markup languages, are more cumbersome and slower. Each sensor has its own sample file that is created to arrange the data that arrives from the NASA data API . The assembled messages from the buffers are used by the Mars Rover and Mission Control units as access classes.

Process Communication

Modules communicate with one another using the Apache Kafka and Java frameworks. The Mars Rover component can communicate with mission control through Kafka services. Every sensor on the Mars Rover receives data via the NASA data API using the sol-id and spaceclk . The serialization of this data results in protocol buffer messages. A brief, well-structured list of name-value pairs constitutes every single message in the protocol buffer. In response to these buffer signals, data access classes are generated with basic accessors for every field and methods to serialize or parse the entire structure to or from raw bytes. These classes are utilized by Mission Control to retrieve messages from the Protocol Buffer, store them, and retrieve them at a later time.

Building the Sensor

All of the components of a state machine must be compatible with one another and with State. It is simpler to incorporate a state-based monitor into the entire project as the rover's kernel is dependent on state machines. The state machine of the sensor, for instance, is merely one of several crucial components. Obtaining data from repositories and immediately storing it are the most crucial duties. We crawl the data ahead of time to decrease the impact as the amount of data becomes a bigger concern. We verify that the local copy has been updated with any new information. Following that, the overhead of the network was reduced. In the first stage, known as the calibration state, the screen is adjusted so that it is in sync with the space clock. The calibration process involves checking the functionality of each measure. After the sensor is constructed, it must be added to the kernel as rover equipment during registration.

SAM Results

The person. To view a screenshot of the Mars Rover simulator's screen arrangement, go to Figure 5.1. After determining the sol id and a reliable ephemeris time, the S.A.M. suite of tools can be examined. Upon selecting the SAM sensor from the user interface, the test is initiated. From "sleeping" to "listening" is the transition the computer makes before the animation engine displays the testergebnisse. The person. Part 5.2 displays a sample result from the SAM set of instruments utilized for the Mars day, sol id="1225," in the course of the research. By assigning sol id="1225," the chemical composition of the material that Curiosity gathered at the Gale Crater site during its Martian day is showcased.

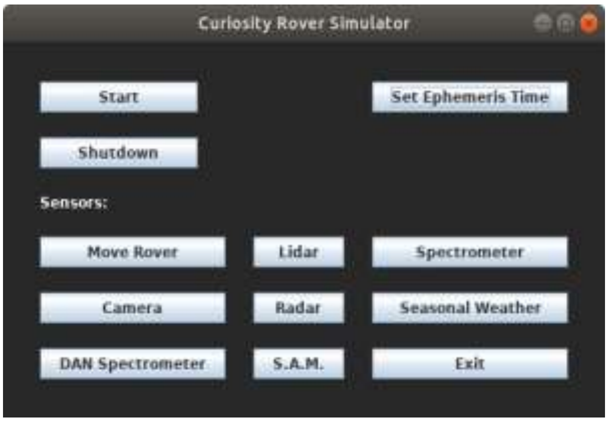

Figure 5.1 depicts the Graphical User Interface createdin order to easily control the Mars Rover Simulator.

Figure 5.2 reflects the readings of the SAM test run withsol id=”1225”

5.CONCLUSION

Animation engine, protocol buffer, sensor module, and reduction in process communication comprise the SAM sensor. Consequently, the comprehensive development of the simulator was finalized, culminating in the establishment of a software replica of the Curiosity Mars Rover.

Future enhancements could potentially be made to the user interfaces and visualizations of the Rover Simulator and the SAM suite of tools, according to our assessment. It is utilized to test machine learning techniques and as a diagnostic instrument. Moreover, it is acknowledged that there exist numerous prospects for deriving sound conclusions through the analysis of sensor data before undertaking human data analysis.

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