EVA Innovation Design Technical Report

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Abstract

A possible space innovation would be to use a FPGA (Field Programmable Gate Array) and a field array of sensors to create a central analytics station for astronauts.This would provide a low cost, hardware based processing acceleration that would interface with existing Space flight technology to provide cloud independent machine learning and analytics to astronauts. With the flexibility provided by an FPGA, complex AI and Machine Learning Algorithms could be effectively designed from the ground up into the silicon wafer and mass produced allowing for an influx of low cost sensors to collect analytics and report it back to a central, in flight processing station which would allow astronauts to quickly visualize data collected from the ship without long and complex processing.

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Data is everywhere in any space mission. Ranging from temperature analytics to velocity and acceleration values, many elements of space travel require quick real time processing, and rapid secure interfacing between the space vehicle and the command center. Space Vehicles operate at a high efficiency, with astronauts performing many tasks, and the lack of a proper, low cost data visualization and analytics device can be crippling. I propose a low cost, hardware accelerated onboard processing unit with easy data visualization and advanced prediction and warning capabilities to help assist astronauts in space.

Function

My device will follow a design process similar to that of the Alibaba Hanguang 800 (Alibaba). Alibaba's microprocessor engineers used the silicon wafer to program the hardware chip to accelerate simple software codes, reducing the overall load on the processing unit, and allowing it to reach nearly 78,563 IPS, making it the fastest AI Chip in the world. Using an array of FPGAs would be much cheaper, although it would be larger. An FPGA is a Field Programmable Gate Array, a mainframe of high speed conductor gates, coded with Versalang ("What is an FPGA"). These gates have the functions programmed into them by the user, while traditional ASIC chips (like Intel Processors) have the instructions pre-programmed, making them much more expensive. The FPGAs allow for manufacturers to only produce what is needed, greatly reducing costs. A group of FPGAs, even if used for small tasks, like a gaussian analysis, or a prediction generation, could help take the load off critical mainframe servers. This data from the FPGAs would then be sent to a central tablet like computer, that would help astronauts visualize the data, and look at patterns and predictions from the data.

Control

The Data visualization device would be controlled onboard by astronauts. The algorithms used by the FPGAs would be coded and maintained by researchers on earth, while astronauts would only be responsible for interacting with the data, and using it to help assist with decisions made in space. A graph and data visualization program, like Dash, or Plot.ly, would be implemented to provide easy to use, quick access to data in an elegant package ("Introduction", DASH Group).

Instructions:

The device would be very simple to use, yet not compromise on functionality. A series of dropdowns and selection filters would help the astronauts quickly pinpoint data trends, relations, and abnormalities with the Space Shuttle system. The touchscreen tablet would provide simplicity, and robustness not found in a complex, traditional analytics system. The device would primarily be used inside the space vehicle, but would be robust, and sturdy enough to be used outside the vehicle if necessary.

Description

The device would consist of 3 main components. The first of which would be the FPGA matrix used to interface with the existing sensors and arrays found on the space vehicle. By using a matrix to interface with different sensors in parallel, devising a seperate sensor system would not be needed, and it would save costs by using legacy and existing hardware. The second component would be FPGA processing matrix. This would consist of a dense, compact cluster of specialized FPGAs that would be unique to individual sensors. This keeps the build costs for individual chips low, and speeds up the processing by not combining different data analytics programs over one ASIC chip, as would be done traditionally. The final component would be the robust tablet, that would use a high speed DASH or Plot.ly application which would provide rapid, simplistic data visualization and insights. The tablets processing power would not be a major concern as it merely relays pre-processed information from the FPGA array, thus increasing the speed of the whole system.

Training

The beauty of the simple design is that astronauts would only need to be trained in how to use the app, and make quick maintenance of the FPGA Array. Since the array would consist of low cost devices, and since nothing is cached locally on each FPGA, each system becomes hot swappable. Astronauts would be trained on how to quickly manage and troubleshoot a microprocessor cluster. They would then be trained on how to quickly swap out FPGA components, and on how to manage power supply issues. These would be done through both physical, and computer simulations. Finally, a quick introduction to the simple app interface would allow astronauts to understand how to benefit from the device.

Conclusion

A high speed data analytics program is necessary for any mission critical application. While on earth, we may rely on centralized, internet accessible computer stations for critical computations and analytics, in Space, such computations must be done locally. As a result, speed, cost effectiveness, and efficiency become the top priorities. To combat this issue, I have developed a 3 stage compute and analytics device, making usage of FPGA Matrices and Python Web Application Framework to create a simple, high speed, hardware accelerated processing device to assist astronauts with data visualization.

References

Alibaba Group. *Alibaba Unveils AI Chip to Enhance Cloud Computing Power*. 25 Sept. 2019.

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