Real-Time Transmission of Images from a Drone

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Introduction

Real-time wireless communication methods enable integrated systems to perform data processing and visualization in parallel with data acquisition. These communication or transmission systems are highly beneficial when the location of data acquisition is inaccessible, established communications infrastructure is damaged, or the acquisition location is extremely dangerous.

Real-Time Communication

Concept Overview

Communication in real time is a flawed description of what can best be described as a transmission with rapid response and minimal latency. This technique facilitates parallel processing of data. Real-time communication relies on extremely fast pre-processing and transmission techniques in order to avoid the buffering of data which can contribute to a longer latency period, the period of time between when the data was acquired and a human or computer operator has access to the information.

Pre-processing clock cycle rate, bandwidth of the transmitter, and power of transmission necessary to obtain a high probability of lossless communication are all factors that can limit the efficacy of a real-time transmission system. These issues play a more significant role when the application of the transmission system is on a drone, which suffers from additional limitations on power consumption and payload capability. A further discussion of these issues in the context of the drone-based application of our project can be found in the last main section of this article.

Preprocessing

Preprocessing of transmission data is the process by which the original data is manipulated into a better format for communication or storage in a cache until it is transmitted. Each type of data obtained needs to be broken down from the original format into a raw bit-stream so that it can be easily fed into a transmitter and sent to a receiver for further computation. Read and write instructions, which are typically used in preprocessing, take a certain number of clock cycles to complete. The more clock cycles it takes to package the raw data for transmission or storage, the more likely it is that new data will come in. If the process isn't complete when the next data point arrives then a queue has to build up which increases the latency time and reduces the effectiveness of real-time transmission.

Transmitter Choice and Bandwidth

There are many types of transmission mechanisms but most of them fail in disaster regions where infrastructure is damaged and transmission distance is long. However, radio transmissions can be set up to work over relatively long distances of around a mile with only a low power setup. The bandwidth, which is synonymous with the amount of information that can be transmitted in a communication packet, may limit the effectiveness of a real-time communication system. Several instructions must be processed to setup the transmission with a new packet. The more packets that information must be split into, the more time it takes in order to transmit the information. As a result, latency which disrupts the real-time aspect of the transmission is highly dependent on the on the bandwidth of the system.

Power Consumption

The power consumption of the system and the requirements to losslessly receive the data are pivotal in the operation of a real-time communication system. As the distance over which information has to be transmitted increases, the likelihood that the data is lost resulting in an inability to effectively parallel process the information also increases. In this event, while the communication can be considered real-time, the result is poor enough as to eliminate the benefits of parallel processing.

There are both directional and omni-directional antennas, which have different power consumption profiles. A directional antenna requires less power but must be kept in line with the receiver, which can be a complicated problem. In the context of a drone based project, establishing this relative orientation during flight can be extremely difficult. In essence based on the angle of arrival the two systems must additionally communicate and perform control algorithms to constantly orient the receiver to the transmitter. While there are benefits to this method in terms of power consumption, it is also significantly more difficult to enact. An alternative to this method is that of using an omni-directional antenna that instead of transmitting in a focused direction radiates outward in all directions. This method requires significantly more power in order to ensure the same reception as before but now at all angles. In the context of the drone this method is of interest in that it eliminates the need to establish a complex control system to orient the two antennas.

Project Specific Considerations

In our senior Capstone project each transmission packet contained a thermal image, a regular image, a set of GPS coordinates, and a radiation sample value. One of the most complicated pre-processing procedures corresponded to the pathway taken by the image data that was collected. The images that were taken by the GoPro® camera had to be stored on an additional SD card that was read/write accessible by an Arduino Pro Mini®. In addition the image had to be processed pixel by pixel to put it in a form that was transmittable via radio. This processing meant that the image had to be broken into a bit-stream such that each pixel was coded independently to ensure that the image could be reconstructed at the receiver.

New images were being captured approximately every one second so the steps of converting the image to a bit-stream if not fast enough to complete in under a second contributed to a growing latency time as more data was acquired. This meant that the first time an image isn't fully transmitted before a new image is taken the amount of lag between the true state and the represented data grew. For this reason a microcontroller with a fast clock rate was chosen in order to facilitate a better real-time transmission system.

Due to the limited infrastructure available in most post-disaster zones we opted for a radio transmitter in our project. While radio, can theoretically maintain a relatively large bandwidth the radio transmitter that we used was originally limited to send data packets that were no more than sixty bytes. This limitation was the result of a First In First Out or FIFO buffer that was part of the transmitter package. A new transmitter could be sourced for our application but there are numerous problems including determining the correct impedance match that were beyond the scope of our development. The data packet size limitation that we operated with was also a large contributor to the amount of latency as more clock cycles needed to be dedicated to setup the additional packets

Within the context of using a radio transmitter the system that we implemented utilized a pair of antennas to serve as transmitter and receiver. In analyzing the issues of communication range we determined that our antennas were directional. This was beneficial in facilitating a low power solution but made it difficult to maintain a communication link during flight, as the antennas had only a narrow angle range in order to communicate. In order to limit complexity, a future application of our work would benefit from a larger scale drone that would be capable of supplying the power needed for an omni-directional antenna.

Conclusion

When discussing real-time communication the true question is of latency relative to an acceptable metric. With proper design a system may be able to produce the power necessary to ensure lossless communication, with an acceptable bandwidth to minimize the number of transmitted data packets, and a fast enough clock speed to perform preprocessing steps before additional data is acquired. If this system can be established with minimal or ideally no additional latency beyond the acquisition rate, then real-time communication can effectively enable parallel processing of data. In the context of post-disaster assistance drones this can speed up the rescue process and save lives.

References

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