Whitepaper

How the Live-CoDec ULD by ITAVA Systems improves unmanned vehicle control

Introduction

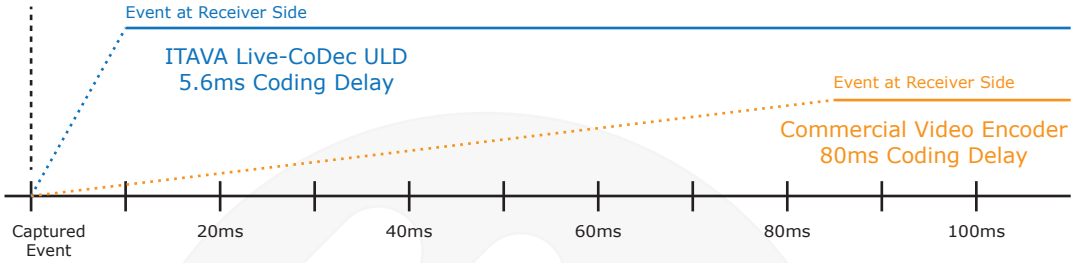
The importance of unmanned ground vehicles (UGV) and unmanned aerial vehicles (UAV) is still rising in civil and military use-cases. In civil first responder scenarios, unmanned vehicles contribute by providing information about critical situations and allow an operator to take appropriate actions from a safe distance. A recent example are the robots used by nuclear technicians at Fukushima (Japan), where they operated in a contaminated, harmful environment. In the military domain, UGVs and UAVs have to cover a wide range of applications from counter improvised explosive device (C-EID) to reconnaissance missions. To meet the new challenges in civil and military applications it is required for the vehicles to support non-line-of-sight operations (NLOS) and a real-time control by the operator. This paper gives a short overview about the common problems of creating a video link for unmanned vehicles and shows how a real subframe-latency-coding can improve the control of UGVs and UAVs under NLOS conditions.

Current UGV/ UAV Control

Today's UGVs and UAVs control systems can be divided into two main technologies – cable-based and wireless. The cable-based solution offers a simple and robust connection to the remote controlled device but is not suitable for UAVs. The cable, which is towed by an UGV, constrains the mobility of the vehicle. To avoid this problem and to run the vehicles without any restrictions there is a need for a wireless control methods. For years it is possible to control vehicles remotely when they can be seen, but to control a vehicle when it is out of sight or working on distant objects, it requires some kind of feedback from the vehicle to the operator. The most common feedback is a video transmission that enables the operator to see what the robot or the robot's tools are doing. A very simple way to transmit video is to modulate an analog video signal to a radio communication carrier. This technique is well-known and proven since the invention of television. However, through the digital revolution, new technologies and methods for wireless video transmission are developed, for example to use a given frequency spectrum more efficiently and to create a more robust signal even under NLOS conditions. Current UGV military applications like reconnaissance or C-IED missions in urban areas require a high mobility combined with a sensitive real-time controllability to be efficient, but the drawback of the new video transmission technologies is the increased complexity of the system. This new complexity leads to processing delays which have a highly negative influence on the controllability.

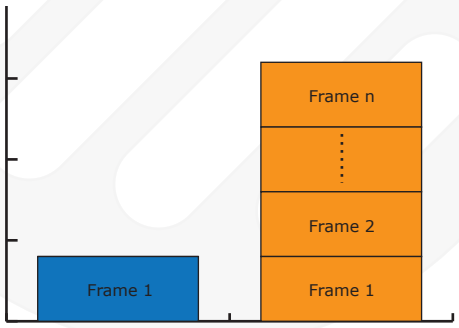
Fighting latency in wireless video transmission

Latency in wireless video transmission systems can occur for numerous reasons, as these systems are highly complex and an elaborate cooperation of all it's components is required. The latency being addressed by this paper refers to the visual delay (lag) in modern wireless video transmission links. By comparing the ITAVA Live-CoDec ULD with common commercial video encoders regarding the entire delay of the video link, the following text shows how sub-frame delay video solutions improve the efficiency of remote controlled vehicles.



Entire Transmitting Delay Comparison (CoDec delay and transmission link delay)

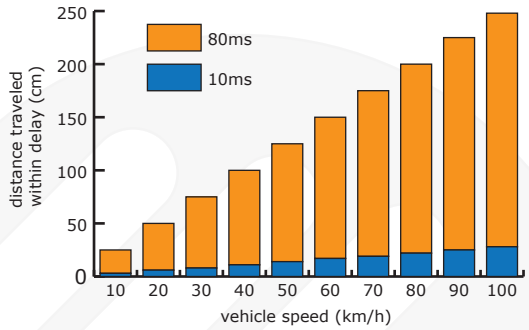
The main cause of latency is the video compression required by the widely used COFDM radio communication. Current methods of compression use preceding video frames to estimate following image data and only transmit differences between images and from time to time a complete index frame. This causes an image loss over the time of several



Startup- & Recovery-Time Comparison

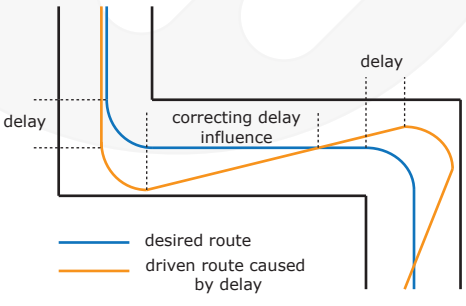
frames if the video link gets disturbed. The ITAVA Live-CoDec only drops the single frame when the communication channel is unstable through noise or active counter measures. With this reaction on connection failures the ITAVA Live-CoDec provides the most stable videostream possible on a given wireless video link and prevents long wait times after a connection loss to deliver the video stream again.

A big influence of visual delay is the deteriorating feedback and coordination while controlling the remote vehicle. The visual feedback of all actions made by the operator is delayed which constrains the possible speed of the device because all events need additional time to reach the operator. Depending on the speed and the transmission delay, the vehicle moves a certain distance while the current state has not reached the operator yet. On high speeds and high latency, this distance can be up to several meters. That means that any action taken by the operator affects the vehicle later than intended. As the result of the described latency problems, the overall operational speed for unmanned remote-controlled vehicles is quite limited to avoid hitting obstacles or leave the desired route.



Latency comparison regarding distance traveled in delay time

An application scenario with rising significance for unmanned remote-controlled vehicles is to use them as a decoy in various situations. Current projects use unmanned versions of actual military vehicles (called "Ghost Ship") to head convoys in dangerous areas. These remote-controlled vehicles should attract the attention of potential aggressors and they also should trigger improvised explosive devices while keeping humans out of harm's way.



delay effects on driving accuracy

While heading the convoy, an UGV has to be as fast as possible to enable a fast escape for all other vehicles in dangerous situations which (using common wireless protocols) may be manageable on a straight road, but not in an actual urban environment. As previously described, all actions by the operator are taken on the basis of outdated video data and thus the action may not be appropriate for the current situation.

ITAVA Live-CoDec

The ITAVA Live-CoDec eliminates the visual delays in digital wireless video links and enables the operator to combine the advantage of analog video transmission (no visible delay) with the digital capabilities like multi-stream transmission, data encryption and the insensitivity of digital radio to signal reflections in urban environments. This allows a higher speed of the UGV, a more precise controllability and minimizes the time required for training and the time required to get accustomed to the delay. Furthermore, the ITAVA Live-CoDec can easily be integrated into common COFDM radio systems because of its portability and the variety of interfaces to upgrade existing wireless video links to a lower latency. In addition to a real-time video connection, the ITAVA Live-CoDec offers the smallest startup- and recovery-times when the radio link gets disturbed. As an IP-Core for programmable logic components, the Live-CoDec is modifiable to meet the customer's requirements and existing configurations. For keeping the radio communication system up-to-date, it is possible to upgrade the Live-CoDec with future developments.

ITAVA Systems

ITAVA Systems is a world leader in the development of low latency video coding and embedded system design. The company combines almost 15 years of experience in the embedded systems area, especially in FPGA programming as well as in image processing and video coding. This experience enables ITAVA Systems to implement customer-specific solutions in programmable logic and provide netlists for tapeout ASICs. The company also provides development services in embedded areas like microcontroller designs.