Field Trials of Using 5G in Video Transmission

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1. Introduction

High-speed and large-capacity communications through a 5th generation mobile communications system (referred to below as “5G”) has a high affinity with the field of video transmission. It is expected to enable the transmission of high-definition video deemed difficult to achieve up to the 4G era, broaden the usage scenarios of new video technologies such as augmented reality (AR) and virtual reality (VR), and drive new developments in video technologies.

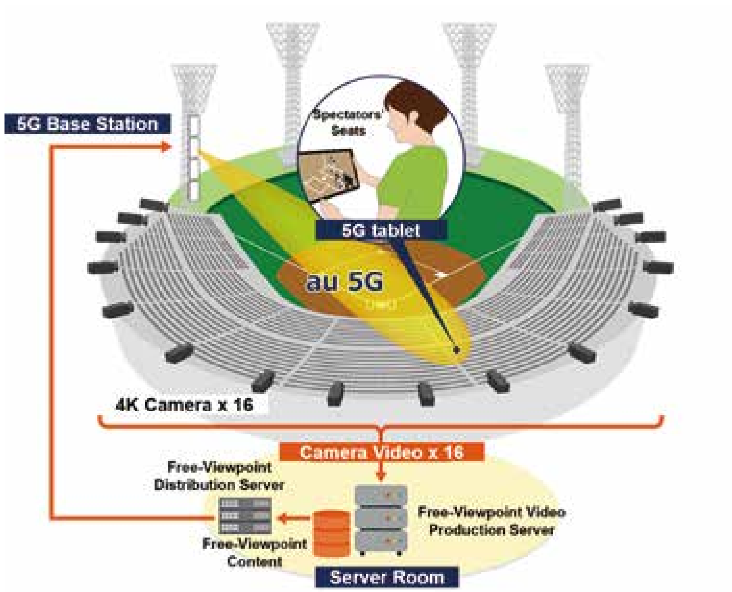
This paper introduces the results of field trials using 5G in video transmission.

2. 5G × real-time distribution of free-viewpoint video

Interest is growing in technologies that can provide users with an even higher sense of presence such as AR/VR as new video-experience technologies of the 5G era. One example of video technologies that can make such high-presence video possible is free-viewpoint video synthesis technology. In the past, it was only possible to view video shot directly by a camera, but free-

■ **Figure 1: Real-time distribution of free-viewpoint video**

■ **Figure 2: System configuration of free-viewpoint video distribution trial**



viewpoint video enables video to be appreciated from a viewpoint not shot by a camera (virtual viewpoint). As a trial combining this free-viewpoint video and 5G, we here introduce a real-time free-viewpoint video distribution trial using 10 5G tablets conducted at a Japanese professional baseball game held at Okinawa Cellular Stadium in Naha in June 2018.

In this trial, the video taken by 16 4K cameras pointed at the batter's box in the field was used as a basis for synthesizing free-viewpoint video from any angle desired by a spectator in real time and to distribute that video to the spectator's seat in the stadium in real time using the high-speed, large-capacity features of 5G in the 28 GHz band. An image of real-time distribution of free-viewpoint video is shown in Figure 1.

The configuration of the free-viewpoint video distribution system of this trial is shown in Figure 2. In this system, the video taken by 16 4K cameras oriented toward the batter's box is sent to a free-viewpoint video production server installed within the stadium to produce free-viewpoint video content in real time. This content is then sent to a free-viewpoint distribution server provided for each user 5G tablet. The users, meanwhile, input viewpoint instructions by touch operations on the screen of their 5G tablets and the system transmits that information to the free-viewpoint distribution server using 5G. This server then synthesizes the free-viewpoint video (2K, 30 fps) corresponding to the received viewpoint information in real time to for distribution to each 5G tablet.

The trial demonstrated that this configuration combined with the large-capacity and low-latency transmission capabilities of 5G enables free-viewpoint video to be displayed approximately 0.5 sec. after a viewpoint input from a 5G tablet. In other words, it showed that the time difference between what one is actually seeing with one's own eyes at a sporting event and the video displayed on the tablet is so small that the user can feel a high sense of presence through interactive viewpoint operations without feeling an uncomfortable time lag. The trial also showed that large-capacity video could be distributed simultaneously to many spectators, which is something that would be difficult for mobile communications of previous generations. A scene of this trial can be seen in a video released on YouTube.[1]

As one example of what this technology can achieve, a spectator sitting on the first-base side can view video taken from the third-base side on one's own 5G tablet and can also rotate, magnify, or reduce the video through touch operations on the tablet. It also incorporates a replay function so that a spectator can take another look at an exciting play such as a home run from various viewpoints. The technology can be applied to stadiums or various types of sporting events where cameras can be installed beforehand and suggests a new sports-viewing style using 5G.

3. 5G × drone

Today, drones are increasingly being used in videography, but the use of 5G with drones is expected to bring about major changes in aerial video applications. For example, the delivery of high-definition video from drones was first made possible by storing the video in camera recording equipment mounted on a drone and collecting the video data after bringing the drone down. However, mounting a 5G terminal on a drone will enable the video from the drone to be relayed in real time. This will enable real-time delivery of high-definition video from angles never thought of before, which should find use in events demanding a high sense of presence. The following introduces two field trials of real-time video transmission from drones using 5G.

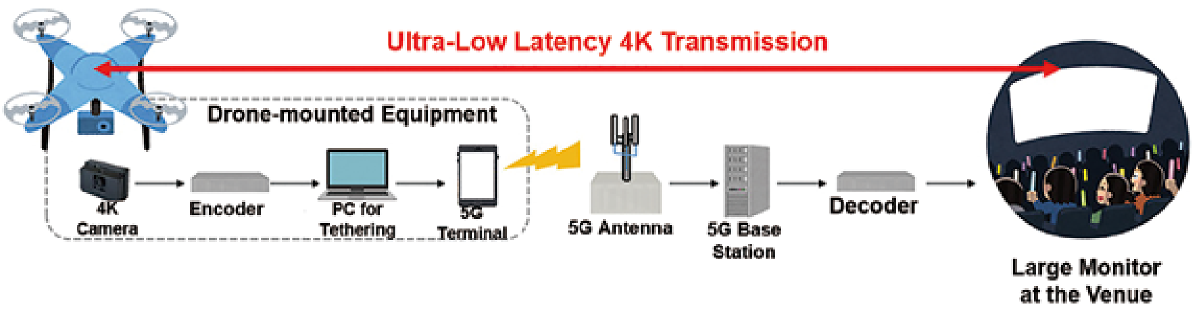
3.1 Real-time ultra-low-latency transmission of high-definition video from drone

This section introduces an example of using 5G-based video transmission from a drone at an event, which was demonstrated at FAI Drone Tokyo 2019 Racing and Conference (DTRC2019), an international drone racing and conference event held at Tokyo Motor Show 2019 in November of that year. In this event, a drone equipped with a 5G terminal and 4K camera was used to capture the scene of a drone race final with 4K, 60 fps aerial video, which was then relayed in real time to a large monitor at the venue using an ultra-low-latency transmission system and 5G in the 28 GHz band. A view of the drone shooting video of the race is shown in Figure 3.

In this event, delay in video transmission could create an out-of-sync feeling between the real movement of subjects and the video displayed on the venue's large monitor. To therefore eliminate this feeling as much as possible, it was necessary to shorten the end-to-end delay from transmitting the video taken by the camera to displaying it on the monitor. In 4K video transmission using conventional encoder/decoder equipment, the delay from video capture to monitor display is long resulting in a delay of several hundred milliseconds due to a compression process. Thus, even if low-latency communications can be

■ **Figure 3: View of drone shooting video of race**

■ Figure 4: System configuration of low-latency 4K video transmission from drone



achieved through 5G, the processing time in encoder/decoder equipment is longer than communication time by an order of magnitude thereby making it dominant, which makes it difficult to achieve low-latency video transmission on an end-to-end basis.

With this in mind, all of the processes from camera input to video output in the ultra-low-latency 4K video transmission system used in this trial were reviewed to reduce the latency, the large-capacity capabilities of 5G were exploited, and video-compression and distribution parameters were optimized such as reducing the compression rate. In this way, the latency from camera capture to video display on the large monitor at the venue was reduced to less than 100 milliseconds and a high-reality video viewing experience of the drone race from above was achieved.

■ Figure 5: Scene from trial of 8K video transmission from drone

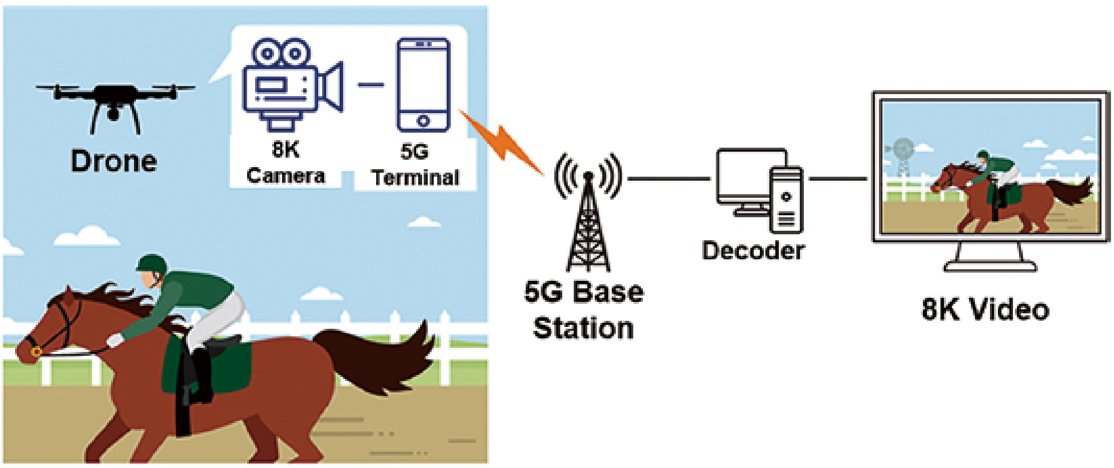
The system configuration of low-latency 4K video transmission from a drone is shown in Figure 4.

The combination of 5G and drones is expected to achieve real-time distribution of exciting video previously unseen, such as video from viewpoints that follow an object moving at high speed or video from inaccessible locations such as overhead points. Additionally, the future spread of drones equipped with a 5G terminal should enable even more users to become video distributors and bring even minor sporting events or activities under the spotlight.

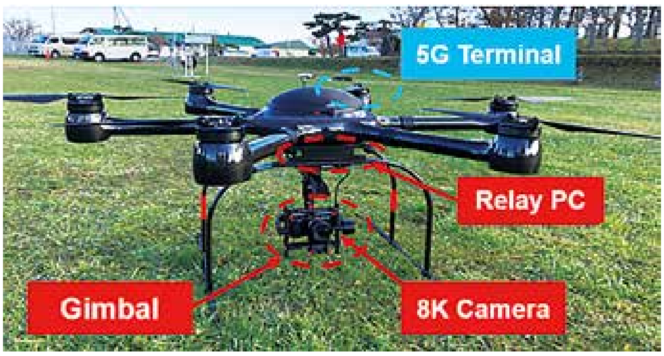
3.2 Real-time transmission of 8K video from drone

The following introduces a trial of transmitting 8K ultra-high-definition video in real time using 5G to observe and monitor a racehorse on a training course from remote locations as a means of supporting racehorse training. This trial was conducted in November 2019 in cooperation with the Hidaka Race Horse Cooperative Upbringing Center in Niikappu, Hokkaido. The trial envisioned a number of uses for this capability. For example, it could satisfy the needs of horse owners, producers, etc. that would like to check on the growth of their ponies entrusted to a cooperative without having to actually go there. It could also be used to convey the charm of horse pastures to people living overseas and to the horse-riding population, to promote tourism to or employment at such pastures, and to even increase the sale of horse-racing betting tickets. This trial was conducted as part of the 5G System Trials by the Ministry of Internal Affairs and

■ Figure 6: System configuration of 8K real-time video transmission trial



■ Figure 7: Devices mounted on drone



Communications (MIC). A typical scene from the trial is shown in Figure 5.

The system configuration of this trial is shown in Figure 6. The 5G system covers the drone flight airspace above the training course at the racehorse training facilities in the 28 GHz band. The drone used for shooting the video mounts an 8K camera, a computer for video relay, and a 5G terminal as shown in Figure 7. The ultra-high-definition video (30 fps) from the 8K camera is delivered via 5G at a transmission rate of approximately 100 Mbps and displayed in real time on an 8K monitor installed within an office. This system can provide vivid views of a racehorse in training through ultra-high-definition video. It can also be used to broadcast high-presence video from a drone of racehorses running at full speed to tourist facilities, transportation hubs, and other sites to generate interest in racehorses and promote tourism, and it could even be used for actual races. A scene of this trial can be seen in a video released on YouTube.[2]

3.3 Summary

As described above, the real-time transmission of high-definition video from a drone by 5G enables distribution of aerial video with a high sense of presence, which was difficult to achieve in previous mobile systems. In addition, we can envision how such a system can be used for live events that require real-time characteristics or for remote piloting of drones by leveraging the low-latency feature of 5G.

As examples of using 8K or other high-quality video transmitted from a drone, we can consider the transmission of high-definition video of sports scenes with a high “you are there” feeling and the use of high-quality video in the maintenance of infrastructure facilities such as bridges that are difficult for people to access. In the latter case, the use of a drone would enable immediate and detailed checking through live distribution of high-definition video without having to send people directly to the target site thereby improving work efficiency.

4. 5G × promotion of new sporting events and enhancement of sense of presence for spectators

5G is expected to be used in sporting events. A new competitive sport called “slacklining” is now being promoted, but problems remain such as insufficient understanding of the rules of the game and the inability of conveying the appeal of the sport. With the aim of solving these problems, a trial was conducted at the 2019 Slackline World Cup Japan FULL COMBO held at Obuse Park in Nagano prefecture in September 2019 using the ultra-high-speed and low-latency features of 5G to provide spectators with a new viewing experience. This trial was conducted as part of the 5G System Trials by MIC.

This trial aimed to make slacklining easy to understand by automatically measuring the height of a slackline player’s jump and displaying that information on the event video even for spectators unfamiliar with the sport. Furthermore, to achieve highly entertaining sports viewing that creates a feeling of oneness with the players, the trial used high-definition video, added production effects to the video, and shared information on a player’s physical sensations (vibration) with spectators in real time

■ Figure 8: Layout of equipment at Slackline World Cup Japan venue

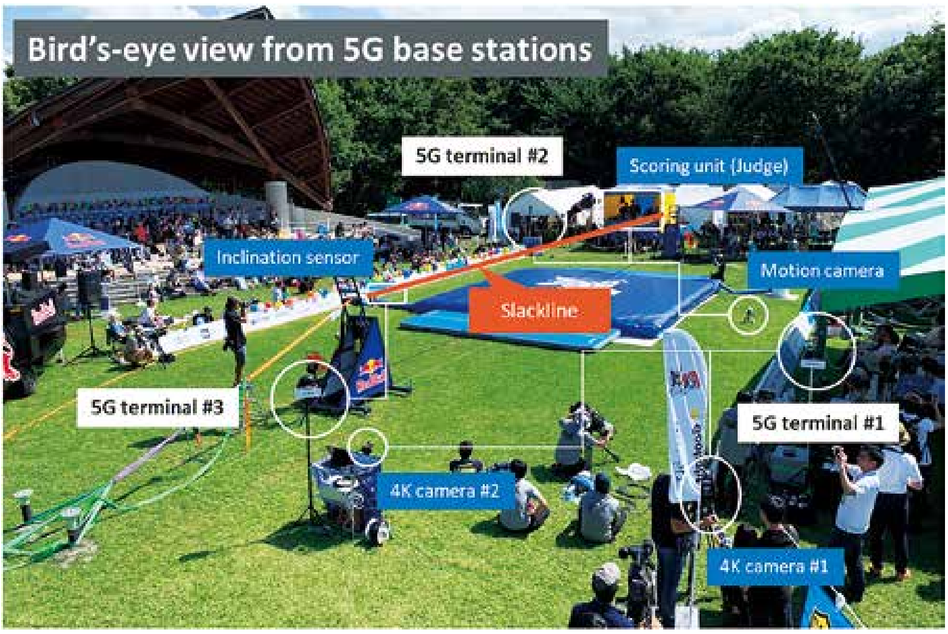
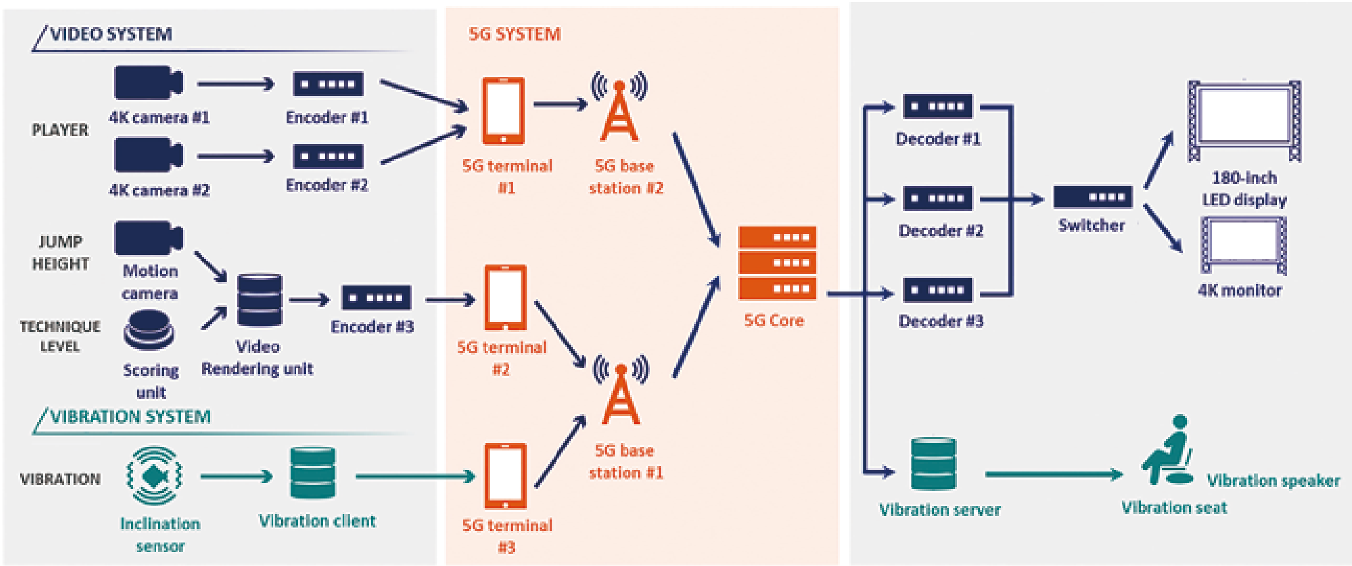


Figure 9: System configuration of video and vibration-information transmission test



using 5G. In this way, spectators could experience the excitement of the competition. The layout of the equipment used in this trial is shown in Figure 8 and the configuration of the video and vibration-information transmission test is shown in Figure 9. Here, the automatic measurement of the height of a jump was accomplished through the use of a motion camera installed in front of the slackline used in the competition. Moreover, in addition to the height of a jump automatically determined from the video of the motion camera, information such as the level of a certain technique as determined by the judge, the number of consecutive jumps, etc. were visualized and transmitted by 5G in the 28 GHz band together with video of the competition captured by 4K cameras (60 fps) and finally displayed in real time on the venue's large monitor. Here, two cameras were installed to capture a player so that angles could be switched flexibly during a performance to provide video viewing from different viewpoints. The end-to-end delay from shooting the video to its output on the large monitor was approximately 300 milliseconds, but since spectators would tend to turn toward the monitor after watching a player's performance, there was no sense of mismatch.

Additionally, as an activity leveraging the low-latency feature of 5G, we conducted a test on delivering the vibration felt by a player when making contact with the slackline to a spectator's seat instantaneously without delay so as to provide a feeling of oneness with that athlete. In more detail, an inclination sensor was installed on the slackline to detect the instantaneous vibration that occurs when the player makes contact with the slackline. The output from this sensor would then be converted to vibration information and transmitted by 5G to a speaker installed on a spectator's vibration seat. This vibration information was delivered in about 40 – 50 milliseconds thereby providing a spectator with a viewing experience having both a feeling of oneness and a sense of presence with the player at the event. A scene of this trial can be seen in a video released on YouTube.[3]

As described above, the large-capacity, low-latency features of 5G were used to help popularize a new competitive sport. In particular, adding information on a player's performance to video promoted understanding of the techniques involved, and conveying information on a player's physical sensations in addition to video helped to provide a new exciting experience. As demonstrated by this trial, we can expect 5G to contribute to the revitalization of regional communities and development of sports by invigorating sporting events rooted in regions or even new sporting events.

5. Conclusion

This paper introduced field trials of applying 5G to various applications using video transmission. The high-speed, large-capacity, and low-latency features of 5G will first and foremost enable the transmission of high-definition video by easing some of the technical constraints that had previously been placed on video transmission. In addition, they can be expected to create new applications and novel user experiences by combining more fully with new technologies.

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