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CHANNEL TRACKING STRATEGY USING SENSOR FUSION FOR UAV MMWAVE MIMO SYSTEMS

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Abstract - *Communications with unmanned aerial vehicles (UAVs) can deliver flexible schedules, enhanced reliability, increased capacities and have become a key component in the integrated air-space network. Unmanned aerial vehicle enabled communications emerges mutually of the many promising solutions of constructing the next-generation extremely reconfigurable and mobile networks. Because of the high frequency of millimetre wave (mmWave) , large antenna array can be packed into a tiny low space, that makes huge multi input multi output applicable for UAV communications. Millimeter Wave huge multiple-input multiple-output(MIMO) system has gained abundant attention for its wide improvement in system turnout. This paper considers that UAV is an Airborne Base Station (BS) in mmWave and proposes an air monitoring method based on the channel control scheme. The 3D geometry channel model is specifically formulated as a combination of information about UAV motion statuses and the chain information, through which a fusion of the flight control system sensors can be obtained and the latter can be calculated by a pilot transmission. To verify the efficiency of the proposed process, simulation results are given.*

***Key Words*: UAV, Channel Tracking, Flight Control System, mmWave, MIMO**

1. INTRODUCTION

Unmanned aerial vehicles have the capability of vertical take-off and landing and high maneuverability, which are widely used as platforms to work in numerous environments. Fifth-generation (5G) mobile networks being actively standardized and employed to support various vehicular communications.5G speeds will range from ~50 Mbit/s to over a gigabit/s. The fastest 5G is known as mm Wave. In the past decade, due to many technological catalysts such as the wireless communications, progress in artificial intelligence, industrial design, unmanned aerial vehicle or drone technologies advance dramatically, which has made these technologies more affordable and accessible to civilian and commercial applications. Millimeter-Wave band (30–300 GHz) has become a potential candidate to meet the ever-increasing traffic crunch for its large available spectrum. However, the unfavorable large path-loss of mmWave band blocks it from practical application [1] [2].
An important use of pilotless aerial vehicles is police investigation of distant targets, wherever device info should quickly be transmitted back to a base station. UAV-aided wireless communications area unit categorised into three major types [3].Initial, UAV-aided present coverage wherever existing communication infrastructure area unit assisted by UAVs for seamless wireless coverage; second, UAV-aided relaying for providing wireless property to distant users or user teams while not direct and reliable communication links; third, UAV-aided info dissemination and knowledge assortment wherever delay-tolerant info and knowledge area unit collected from distributed wireless devices, e.g., internet of things applications. . In general, mmWave band and multiple antennas area unit adopted by UAV communications [1].The combination of mmWave and multiple antennas might inspire their individual advantages: on one hand, tons of or perhaps thousands of antennas is packed into a tiny low UAV with restricted payload than to the metric linear unit level wavelength; on the opposite hand, the antenna array might bring prosperous spatial gain to combat the big path-loss of the mmWave band.

We propose a powerful method to monitor channels for the UAV MIMO communication systems of mmWave in this letter. The 3-dimension (3D) geometry channel template is specifically formulated as a combination of information about the UAV movement state and information about the channel. In order to obtain UAV movement information, a Kalman filter-based sensor fusion is used, while a few pilots are used to extract the information about the channel. To verify the efficiency of the proposed process, simulation results are given.

However, in mmWave communications for UAVs there are many main challenges: Because of the high isotropic path loss mmWave is transmitted in short, electrolyte able beams, and fast beam-tracking and steering require reliable communication. In high-speed flight such follow-up can be a challenge. In addition, the visual line links may be obscured by buildings and other obstacles in the area usually within a range of 10–20m, resulting in intermittent communication. This paper has two broad purposes: one to evaluate the performance requirements and latency for offloading to the edge of drone control with regard to the public safety environment; and second to assess the feasibilities of mmWave accesses for this mission.

2. RELATED WORK

An angle domain hybrid precoding and channel tracking methodology by exploring the spatial options of mmWave huge MIMO channel is projected in [4]. The amount of the effective spatial beams or equivalently the RF chains, is hugely minimized through the operation of spatial rotation. The users area unit then scheduled by the angle division multiple access theme, that bulk users in step with their direction of arrivals. Meanwhile,a channel tracking methodology is meant for the next knowledge transmission through a little variety of pilot symbols. Specifically, the channel info is split into the direction of arrivals info and also the gain info, wherever the direction of arrivals info is half-tracked by a changed unscented Kalman filter and also the gain info is calculable from beam training. The pure mathematics primarily based stochastic model is employed to characterize the UAV huge multiple input multiple output channel, and also the user kinematic equation is usually recommended to alter the channel trailing procedure. However, this methodology needs the priori user kinematic equation, and would be not applicable to UAV communication systems. Now, hybrid precoding that consists of each digital precoding and analog precoding has drawn important attention. Because the potential gains of mmWave huge MIMO depend upon the right channel state info, numerous works are dedicated to finding channel estimation problems. A complicated channel tracking methodology for hybrid mmWave huge MIMO remains anticipating investigation [5].

3. MODULE DESCRIPTION

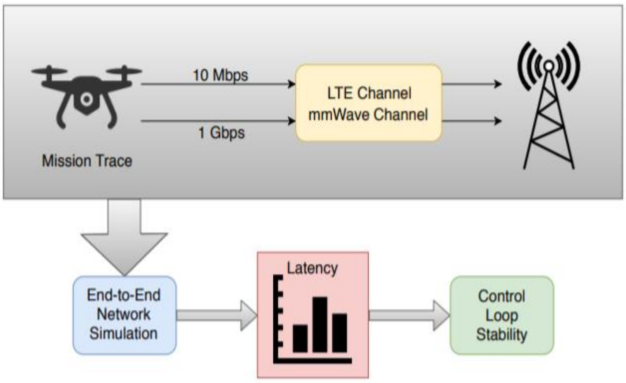

Fig -1: Performance Evaluation Diagram

To conduct the assessment, in environments that are close to the manoeuvring of safety environments, we have collected accurate motion tracks for real drone flights. Place, speed and orientation are the move traces. In this flight, we then simulate a hypothetical mmWave connection using the comprehensive network simulator outlined in [6]. The effect of beamforming is a key challenge in mmWave aerial communication is also important in this simulation. The complete upper layer of 5G mobile network protocol stack is also modelled. Then the simulation provides throughput patterns and in the drone control discharge the impact of latency can be evaluated.

3.1 Unmanned Aerial Vehicle

The Communications of Unmanned Aerial Vehicles is a promising solution for versatile coverage in mobile networks in 5th generation. Unlike terrestrial communication systems, UAV communication can deliver greater capacity and reliability over far longer distances, allowing seamless broadband connectivity. Generally speaking, the UAV communications are used to band mmWave and multiple antennas because the combination of these two aspects could inspire its respective advantages: the antenna array could, on the other hand, pack hundreds, or thousands, of antennas with a limited payload into the small UAV with the millimetre wavelength.

3.2 Channel State Information

UAV communications efficiency depends on the availability of the channel state information (CSI). Unlike ground contact, because of the continuous navigation, the channel between the UAV and ground terminals usually varies over time. The air-to-ground propagation channel was a complete channel sounding and designing method which show that a majority of the total UAV energy from the Line of Sight communication will reach users. For the massive MIMO systems of mmWave, angle division multiple access method has been developed where the UAV massive MIMO channel is characterised by the use of a geometry-based stochastic model [7], and the user-filming equation is suggested as a facilitation for the channel tracking procedure. This form, however, needs the user's film equation and does not apply to UAV communication systems.

3.3 Three Dimension

In this letter, the mmWave UAV MIMO communications systems are being used to tracks an effective channel. The 3-dimensional geometry channel model is specifically formulated as a combination of knowledge about the movement of a UAV and data about the channel. The Kalman filter based sensor fusion is then optimised for obtaining information about UAV motion, while several pilots are used to obtain information about the channel. To verify the efficiency of the proposed process, simulation results are given.

3.4 Flight Control System

The flight control system (FCS) is the key component for UAV navigation, consisting mainly of several sensors, including GPS and MIC (MIMU). The outputs for channel tracking are integrated here to decrease overhead training and energy usage and channel tracking strategies can be seen. The FCS is normally mounted on a body frame, the xb, yb and zb axis of which are mounted respectively in the UAV direction, forward or up. In addition, the UAV navigating frame (n-frame) is chosen as the local geodetic frame that points north, east, and down, respectively, on the xn, yn-axis and zn-axis. In addition, at the middle of the planet, the origin of the inertial frame is the zeal axis parallel to the earth spin axis and the xe-axis indicating the mean of the vernal equinox, and the ye-axis is orthogonal to the xe-axis and the ze-axis.

4. SYSTEM MODEL

4.1 3D Geometry based UAV Channel Model

Massive MIMO and 3D beamforming are known as key technologies for future mobile cellular networks. Their investigation needs channel models that take into account not solely the azimuth angle however additionally the elevation direction. Recently, the third Generation Partnership Project (3GPP) has discharged a replacement 3D spatial channel model [8]. It supports planar antenna arrays and permits to scrutinize ideas like elevation beamforming and full dimension MIMO. Consider a communications scenario in which a UAV base station has M×N uniform rectangular arrays facing downwards and K ground terminals are dispersed across the coverage area. We believe that the channel difference is mostly due to UAV movements because UAVs manoeuvre much faster than land users. Figure 1 shows a detailed diagram of the UAV communication scheme.

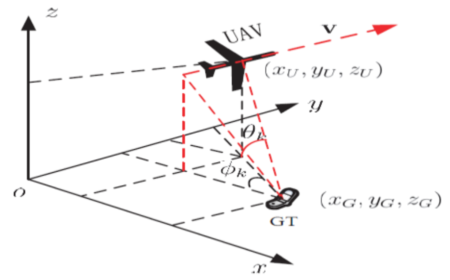

Fig -2: UAV communication system model

Position of UAV represents as r_U =(x_U, y_U, z_U) while r_k = (x_k, y_k , z_k) is the position of ground terminal k. ϕ_k represents the azimuth angle and θ_k represents the elevation angle of user k seen by UAV. Denote A(ϕ_k, θ_k) ∈ $C^{M\times N}$ as the steering vector of UAV,whose $(m,n)^{th}$ element can be expressed as [9]

$$\mathbf{A}(\phi_k, \theta_k)_{(m,n)} = e^{j\frac{2\pi d[(m-1)\sin\phi_k\cos\theta_k+(n-1)\sin\phi_k\sin\theta_k]}{\lambda}} \tag{1}$$

Where λ is the signal carrier wavelength

The 3-dimension M×N geometry based air-to-ground channel model from ground terminal k to UAV can be formulated as [4] [10].

$$\mathbf{G}_k(t) = \frac{\alpha_k}{[D_k]^\gamma} e^{-j[2\pi f_d t T_s \cos\varphi_k+\gamma_k]} \mathbf{A}(\phi_k, \theta_k) \tag{2}$$

Where α_k and γ is the small-scale fading coefficients and the large-scale fading coefficients respectively, D_k is the distance between ground terminal k and antenna, f_d is the maximum Doppler frequency and T_s is the system sampling period. UAV channel tracking can be translated to tracking the UAV movement states and estimating the UAV movement unrelated parameters and in each block.

4.2 Channel tracking by sensor fusion

The aircraft state data is sent by position and movement sensors. sensitiveness sensors treat external data, like distance measuring, whereas external and internal exproprioceptive sensors correlate. UAVs need control software elements and hardware components that will enable the aircraft to be controlled remotely either directly by a pilot or autonomously by an aboard pc. UAV flight dynamics square measure extremely variable and non-linear, therefore maintaining perspective and stability might need continuous computation and readjustment of the aircraft's flight systems. components on the bottom can type a region of a communication system Station and can include a electronic equipment and datalink for human activity with the UAV, a joystick for manual management of the aircraft and ground control station software system. components on board the aircraft include the autopilot, a datalink for human activity with the ground control station, and peripherals like external magnetometers and world navigation satellite system receivers. The control system is that the key half for UAV navigation, that primarily consists of many sensors like GPS and mechanical small inertial unit. The UAV positioning and channel following could be a typical nonlinear procedure. Unscented Kalman filter [11] could be a well known nonlinear filter and would function as a good approach.

5. SIMULATIONS

In this section, simulations are provided to demonstrate the effectiveness of the proposed method. The performance metric of the channel tracking is taken as the normalized mean square error. Chart -1 shows the channel tracking performance of the proposed method. We can see clearly that the mean square error of channel tracking decreases with the increase of signal to noise. Besides, the performance of the proposed method is comparable to the method where the UAV location is aware. After, we also investigate the effects of direction of arrival errors to channel tracking, where $\Delta\emptyset$ and $\Delta\theta$ represent the mean azimuth angle and elevation angle error. It can be seen that there exists error floor in the presence of direction of arrival error, since the direction of arrival misalignment would lead to large performance losses of channel tracking. The key of channel tracking for UAV communications would be the availability of the precise direction of arrival tracking [9].

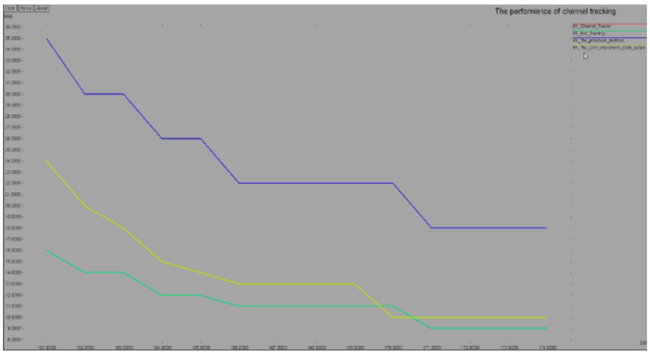

Chart -1: Performance of channel tracking

The flight control system consist the sensor named mechanical micro inertial unit and global positioning system. The outputs of these sensors for channel tracking to decrease the training overhead and energy consumption. Chart -2 shows the graphical representation how the flight control system process the graphics processing unit and mechanical micro inertial unit.

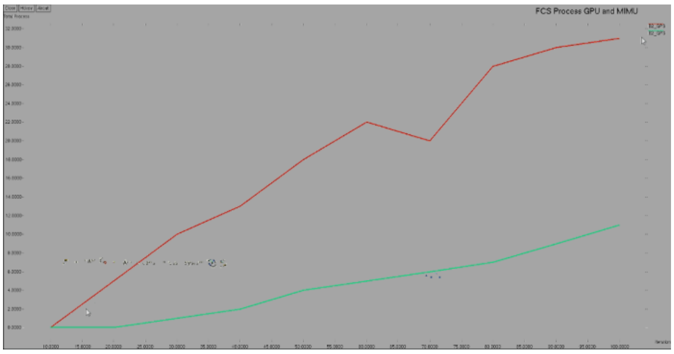

Chart -2: FCS process GPU and MIMU

6. CONCLUSIONS

In this article we have proposed a UAV channel monitoring system based on FCS for mmWave MIMO communications. The 3D geometric channel model was suggested to describe the spatial channel, where UAV movement status and remaining channel information could be provided to determine the channel. In particular it proposed to extract information about UAV movements from the positioning estimating process, while a few pilots monitored the remaining gains. By using UAV movement information, the proposed method provides much lower overhead training compared to the previous approach. The efficiency of the proposed method was checked by simulation results.

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