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Arduino Based Multiple Nodes Access of Wireless Beam Modulation for 6G

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ABSTRACT: For the sixth-generation (6G) communication, it is required to support the massive Internet of Things (IoT) devices with high data rate applications such as vision-based sensors. Unfortunately, the current sub-6 GHz band is already congested, and lower-band communication is hard to support the high data rate transmission. The Millimeter Wave (mm Wave)-based communication technology is a promising solution to support the high rate transmission in a new band. However, the high power consumption and hardware cost of the mm Wave communication system violates the low-cost design principle of IoT devices, which is a heavy burden for the mm Wave application on IoT. In this work, we propose multiple IoT nodes access-based wireless beam modulation (WBM) technology for the mm Wave transmission, where the WBM employs the over-the-air modulation to achieve the low-cost mm Wave hardware design with hundreds of megabit per second transmission.

KEYWORDS: modulation, MIMO, VLC system, network.

I. INTRODUCTION

The sixth-generation (6G) communication is envisioned to provide emerging services and applications with superior performance to 5G [1, 2]. Meanwhile, massive 6G-enabled Internet of Things (IoT) devices will be connected to support advanced intelligent services, such as manufacturing robots, drones, and self-driving cars [3–5]. Consequently, the design of ultra-low latency, ultra-low power, and low-cost communication system is ultra-important for the future 6G-enabled IoT system [6, 7]. Therefore, the hardware constraints will be a critical factor for the 6G-enabled IoT communication system design as the emerging of new radio access technologies. The current IoT-based communication systems, e.g., Lora, Nb-IoT, and Zigbee, are operated in the sub-6 GHz band [9]. However, the congested band usage of the sub-6 GHz band will limit the massive access of 6G-enabled IoT devices [10]. As communication technology advances from 5G to 6G, the development of society will put forward higher requirements for low-latency and high-speed communication scenarios. In particular, demand-driven enhanced mobile broadband (eMBB) based big video services will occupy a long-term advantage in the 5G and 6G industries. For example, augmented reality (AR) and virtual reality (VR), wireless home entertainment, etc. all have requirements for ultra-high-definition video data transmission.

II. OBJECTIVE

To familiarize students with Arduino as IDE, programming language & platform. To provide knowledge of Arduino boards and basic components. Develop skills to design and implement various smart system application.



III. LITERATURE SURVEY

The emerging of Millimeter Wave (mmWave)-based communication, operated in 18GHz-100GHz, provides a new design perspective to solve the congested band problem [13, 14]. Meanwhile, the high-frequency band can support much higher transmission bandwidth than the sub-6 GHz communication system, which can provide Gigabits per second transmission. Due to the short wavelength of mmWave, a large-scale antenna array can be packed in a small area, which can compensate for the high path loss of mmWave signal transmission by employing the massive multiple-input and multiple-output (MIMO) beamforming technology [15]. However, the challenges of mmWave communication applications on the IoT system are the high energy consumption and hardware cost. For instance, a typical mmWave transmitter requires more than 10 Watts power consumption and 2000 dollars hardware cost, which is both far beyond the cost of a vision sensor [16]. The hybrid beamforming (HB) is proposed to solve the high hardware-cost and power consumption of mmWave-based massive MIMO system [17, 18]. In the HB system, the analog beamforming is combined with the digital beamforming, where the analog beamforming provides lower-cost hardware implementation than that of beamforming, and the digital beamforming has higher beamforming freedom than analog beamforming. To further reduce the hardware cost of the HB based mmWave system, a hardware-efficient analog network structure for hybrid precoding is proposed in [19], which only requires a small number of phase shifters with quantized and fixed phases.

IV. METHODOLOGY

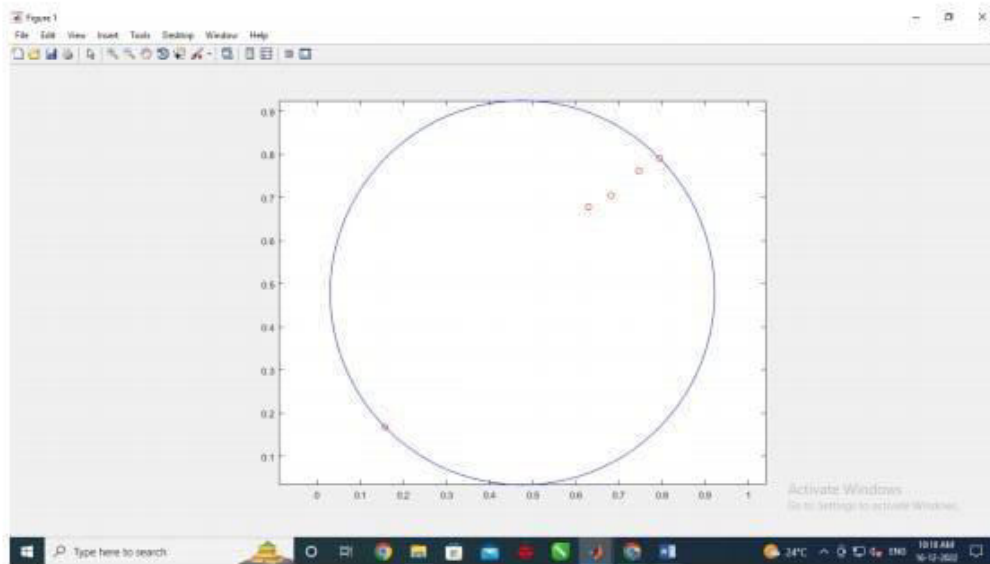
- 1) Protocol Design for Multiple IoT Nodes Access. We design a protocol for multiple IoT nodes access in WBM, which integrates the beam alignment process and multiple IoT nodes orthogonal access. The proposed access protocol supports hybrid grant-based and grantfree access [7], which achieves a good balance between robustness and low latency IoT access.
- 2) 2) Fast Beam Alignment. To facilitate the access process, we employ a shared multiple-beam search algorithm for beam alignment, which divides the searching space into multiple sectors. Then, the RF module pairs of multiple IoT nodes are shared for the parallel beam search. The parallel beam search process can reduce the beam alignment time from 800 us to 100 us based on the proposed WBM hardware scheme.
- 3) 3) Robust Beam Estimation. The channel estimation of WBM is performed by pilot detection and beam energy estimation. We propose an iterative pilot cancellation beam estimation to estimate the transmit pilot signal with its energy. The correlation property is first employed to find the transmitted pilot signals and latency. Then, we employ the Bayesian Gauss-Markov Theorem to estimate the pilot energy. Furthermore, we iteratively subtract the pilot signal with the largest energy to reduce the interference for rest pilot signals, to improve the robustness of beam estimation.
- 4) 4) Performance Evolution of WBM. To illustrate the performance of WBM, we perform multiple simulation tests, including bit error rate (BER), the success rate of pilot detection, and the access latency. We also illustrate the hardware demo for the proposed WBM. The implementation results indicate that WBM has much higher energy efficiency than the current mmWave based platform, while provides a larger transmission rate than sub-6 GHz IoT communication systems.

V. APPLICATION

6G will also enable immersive communication experience through location and context aware digital services, sensory experiences, such as truly immersive extended reality (XR), and high-fidelity holograms. Look for virtual reality, which usually requires a cumbersome headset, to be replaced with augmented reality. 5G and 6G use wireless spectrum of higher range of data transmission faster than 4G, 3G and 2G Networks. However, when comparing 5G vs 6G, the former one is allocated for low band and high band frequencies-sub-6GHz and above 24.25GHz.

VI. RESULT

The proposed method exhibits significantly superior transmission rate and BER performance than the traditional sub-6 GHz communication system, while much higher energy and efficient hardware design than the current HB based mmWave system.



37

```

1  clear
2  close all;
3  close all;
4  function [D, Nk, No] = Optimal_train_Explosion(train_features, train_targets, param, region)
5  [Dk, Theta] = process_param(param);
6  [Nk, No] = select_train_features();
7
8  %Train a randomly large network to random nodes
9
10 %Initial Training a neural network with ' random nodes '
11 [E, Nk, No] = Backpropagation_Backtrain_features, train_targets, [Nk, Theta, 0.1], region;
12
13 train_targets = (train_targets+0.0)*-1;
14 mean = sum(train_targets)/length(train_targets);
15 train_targets = train_targets - mean*ones(1, length(train_targets));
16
17 J = 0;
18 gtwd = 0;
19
20 %Compute all the weights
21 W = [Wk(1) Wk(2)];
22
23 %Define initial W's
24 Wk(1) = 0;
25 Wk(2) = (length(Wk)-1)*eye(length(Wk));
26 Lk = [1 0];
27 param = [length(Wk)];
28
29 %Print the initial W's
30 while (gtwd < Theta) & (length(unique(Lk)) > 1);
31 %Compute Wk(1) by equation 70, DSS Chapter 8
32

```

VII. FUTURE SCOPE

The enhanced connection density will make a large number of connected devices interact with each other in real-time. Also, 6G Will optimize M2M interaction by improving network reliability more than 100 times and reducing the error rate by 10 times.

VIII. CONCLUSION

In this paper, a new vision on the mmWave based 6Genable IoT transmission is presented in the perspective of wireless beam modulation, where the multiple IoT nodes access mechanism is endorsed, and the access protocol, beam



alignment, and beam estimation are handled. The proposed method exhibits significantly superior transmission rate and BER performance than the traditional sub-6 GHz communication system, while much higher energy and efficient hardware design than the current HB based mmWave system. It is believed that the proposed work bridges the gap between the mmWave communication system and the 6G-enable IoT transmission system, which may have great potential in guiding designs in the future IoT radio design. The research area is still broadly open for research and could be extended in many interesting directions, such as the optimization in the high mobility scenario, radio relay for long-range transmission, and high integration IC design.

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