Demo: Wireless Video Streaming for Ultra-low-power Cameras

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ABSTRACT

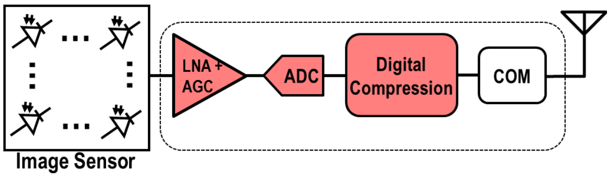
Wireless video streaming has traditionally been considered an extremely power-hungry operation. Existing approaches optimize the camera and communication modules individually to minimize their power consumption. However, designing a video streaming device requires power-consuming hardware components and video CODEC algorithms which makes battery-free video streaming currently infeasible. Existing RF-powered wireless camera prototypes require extensive duty-cycling on the order of tens of minutes, to capture, process and communicate a single frame. Self-powered cameras can capture an image once every few seconds, but do not have the capability to stream video wirelessly.

To understand this case, let us look at the different components in a video-streaming device 1(a): optical lens, video compression and communication. Optical lens is an array of photo-diodes connected to amplifiers and an ADC to translate the analog pixels into digital values. A video CODEC then performs frame compression to compress video, which is then transmitted on the wireless medium. Existing approaches optimize the camera and communication modules separately to minimize their power consumption. However, designing a video streaming device requires power consuming hardware components and video CODEC algorithms that interface the camera and the communication modules.

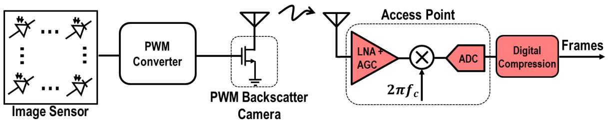
We present the design of an ultra-low-power video streaming device 1(b). We create "analog" video backscatter system that does not use amplifiers, ADCs and AGCs. At a high level, we feed analog pixels from the photo-diodes directly to the backscatter hardware. We achieve this by connecting the antenna to an array of photo-diodes whose output voltage/impedance varies as a function of the pixel value; thus, eliminate power-hungry hardware components including amplifiers, AGCs and ADCs. Such an approach would have the added benefit that the video quality scales smoothly with a varying wireless channel, without the need for explicit rate adaptation. We present our video streaming architecture with more details in [1, 2].

We implement a prototype of our backscatter design on an ultra-low power FPGA platform using a 112×112 gray-scale random pixel access camera from CentEye, which provides readout access to the individual analog pixels. The prototype of our video streaming device burns as low as 2.36 mW while streaming live video at 13 fps. Our access point (AP) consist of two components. We use RTL2832U SDR to receive backsactter signal from the tag and Semtech SX1232 and SE2435L-EK5 power amplifier to generate helper signal. We demonstrate real-time display of video frames using Python scripts which interfaces with the SDR. We evaluate our prototype under different conditions to study its performance under different room lighting conditions and different distances from the access point. We can stream at 7–13 frames per second at distances of up to 27 feet from the AP. We show a video of our real-time demonstration in following link.

https://youtu.be/n7rwpkB3DBQ



(a) Conventional Camera Design



(b) Our Camera Design Approach

Figure 1—The amplifier, AGC, ADC and compression module consume orders of magnitude higher power than what is available on a low-power device. In our design, these power hungry modules have been delegated to the access point eliminating their power consumption overhead from the wireless camera.

1. REFERENCES

[1] S. Naderiparizi, M. Hessar, V. Talla, S. Gollakota, and J. R Smith. Towards battery-free {HD} video streaming. In NSDI 2018.

[2] S. Naderiparizi, M. Hessar, V. Talla, Shyamnath Gollakota, and Joshua R Smith. Ultra-low-power wireless streaming cameras. arXiv preprint arXiv:1707.08718, 2017.

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