Demo Abstract: AXSERBUS: A Quality-Configurable Approximate Serial Bus for Energy-Efficient Sensing

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Mobile, wearable, and implantable devices integrate an increasing number and variety of sensors such as microphones, image sensors, and accelerometers. These devices spend significant amounts of time reading the sensors within them, thereby incurring significant energy dissipation over off-chip serial interconnects. Considering the high data rate in modern sensors and the high energy cost per bit of off-chip buses, a low-power off-chip data transmission scheme is highly demanded. We introduce a quality-configurable approximate serial bus called AXSERBUS for reducing the power consumption of off-chip sensory data transmission by trading data accuracy for energy efficiency.

Since sensors convert attributes of the physical world, such as light, temperature, or vibration, into a digital value, their outputs inherently include noise. Hence, the algorithms that process sensory data are designed to tolerate noisy inputs. For example, a small amount of noise in the readings from an accelerometer in a pedometer will not result in a significant error in the step count, which is what the user is ultimately interested in. Using traditional off-chip serial buses for reading data from such sensors essentially amounts to *transferring noisy data precisely*, which is an overkill and wastes energy. *Approximate computing* exploits the error resiliency of applications to save energy by relaxing the exactness requirement and producing results that are just good enough. Adopting this broad approach, *approximate serial bus* techniques have been proposed to encode data in a *lossy* manner to reduce bit transition counts (TC), leading to reduced switching power in the serial bus.

AXSERBUS encodes data in three modes: (i) If the differential between the current and previous data values is very small, the differential is zeroed out, and a 0-TC (no intra-word TC) pattern is transmitted, and the receiver reuses the previous data value. (ii) If the differential is in an intermediate range (defined by adjustable thresholds), an approximate value of the differential is encoded as a 1-TC (single intra-word TC) pattern, which incurs minimal energy dissipation since it only contains a single bit-transition. The use of approximate differentials allows a wider range of differentials to be encoded in this energy-efficient encoding mode. (iii) Finally, if the differential is large, we transmit the absolute value and not the differential. The energy cost for transmission of the absolute value is relatively high because it may contain several signal transitions, but only a small fraction of data are encoded in this mode. AXSERBUS does not require extra bits to indicate the encoding mode because the mode information is implicitly communicated using the TC of each codeword.

Fig. 1 shows the hardware block diagram of the encoder and the decoder of AXSERBUS, where D_0 and D_m are thresholds to determine the encoding mode. Fig. 2 shows that the serial transition count (STC) decreases, average absolute error (AAE) increases, and the average rate of bit 1's per codeword increases, respectively. Fig. 3 shows the image quality and STC reduction for different threshold settings.

At the University Demonstration, we will demonstrate the performance of AXSERBUS. We implemented AXSERBUS and previous approximate serial encoding techniques on Matlab. They encode and decode the same image captured by a webcam, and the reduction in TC and quality degradation will be compared. Our paper on AXSERBUS will be presented at ISLPED 2017 [5].

- **YouTube video link: `https://youtu.be/W2DLHWpjQZY`**

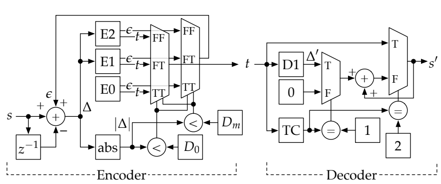

Fig. 1: Encoder and decoder block diagram.

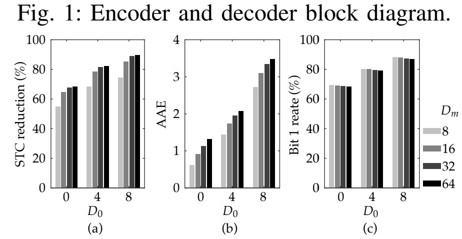

Fig. 2: (a) STC, (b) AAE, and (c) bit 1 rate as D_0 and D_m vary.

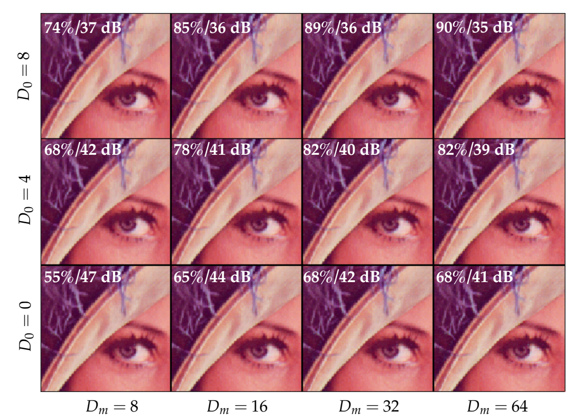

Fig. 3: Magnified test image after encoding and decoding with different threshold configurations.

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