

Anil Kumar Yerrapragada*, Jeeva Keshav Sattianarayanan †, Radha Krishna Ganti‡

Email: *anilkumar@5gtbiitm.in, †jeevakeshavs@smail.iitm.ac.in, ‡rganti@ee.iitm.ac.in

Formats 1, 3, and 4 are suitable for applications requiring
gain.

I
[c
4

(1) Hybrid Automatic Repeat Request (HARQ) acknowledge-

allocation.

five formats). Smaller UCI payloads of 1 or 2 HARQ bits and/or an SR are transferred using Formats 0 and 1. Larger reports, are transmitted using Formats 2, 3, and 4. Furthermore,

Madras [7].

For			symbols	Blocks	Waveform	Modulation	DMRS	Multiplex-
0	HARQ, SR	Short	1-2	1	CP-OFDM	None		
1	HARQ, SR	Long	4-14	1	CP-OFDM	BPSK or QPSK	Yes	Yes
2	HARQ, SR, CSI	Short	1-2	1-16	CP-OFDM	QPSK	Yes	No
3	HARQ, SR, CSI	Long	4-14	1-16 ¹	DFT-S-OFDM			
4	HARQ, SR, CSI	Long	4-14	1	DFT-S-OFDM	$\frac{n}{2}$ -BPSK or QPSK	Yes	Yes

$$r_{u,v}^{\alpha}(k) = e^{j\alpha k} \cdot \bar{r}_{u,v}(k) \\ = e^{j\alpha k} \cdot e^{j\phi(k)\pi/4}, \quad (1)$$

where $k = 0, 1, 2, \dots, N_{sc}^{RB} - 1$ and $\phi(k)$ is given by Table

- AI/ML models must adhere to certain complexity, mem-

bits.

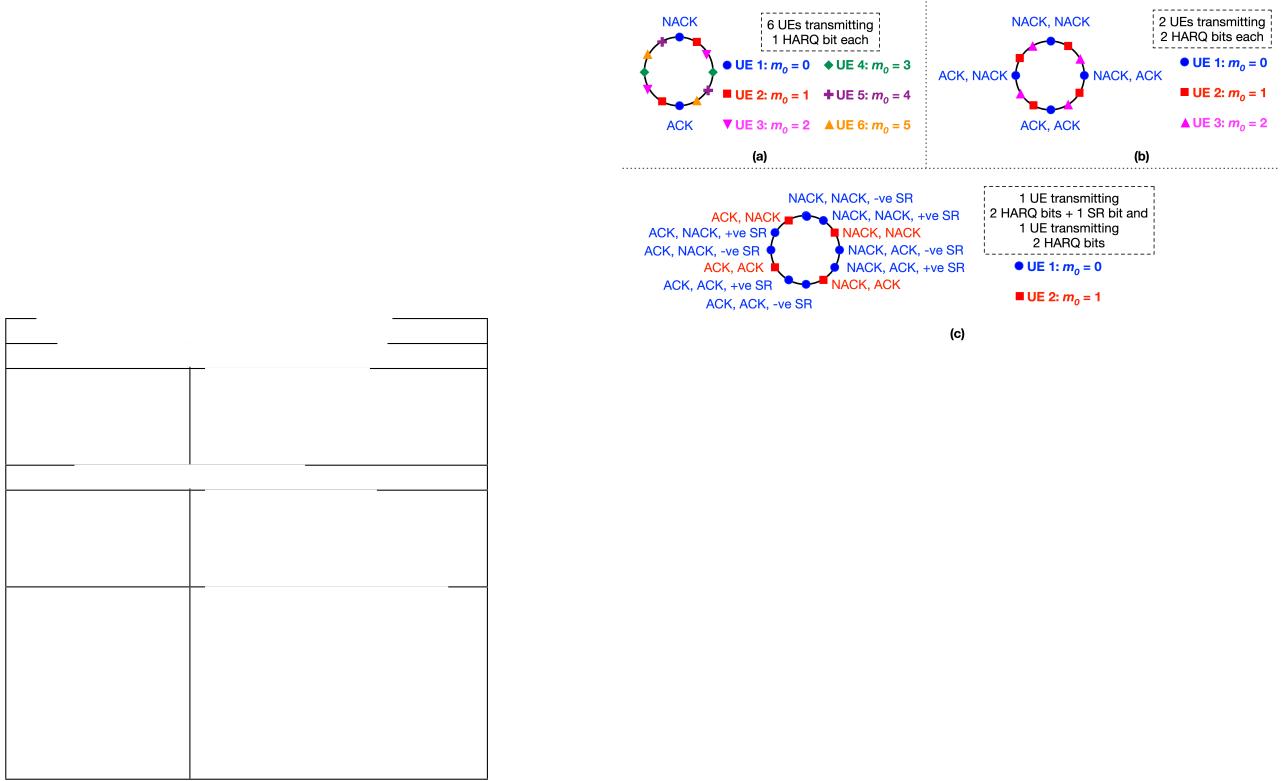
$$_{N_{sc}^{RB}} \left((m_0 + m_{cs} + n_{cs}(n_{s,f}^{\mu}, l + l')) \bmod N_{sc}^{RB} \right), \quad (2)$$

$$\text{II.} \\ \bullet \quad n_{cs}(n$$

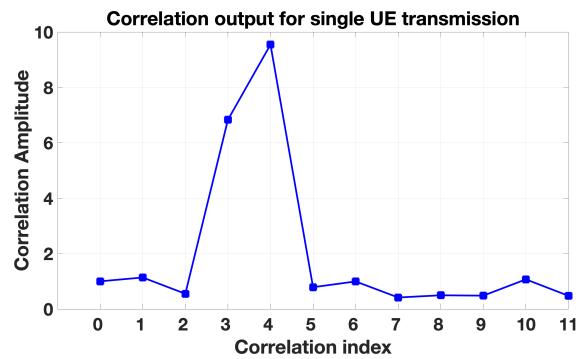
– n

Encoding

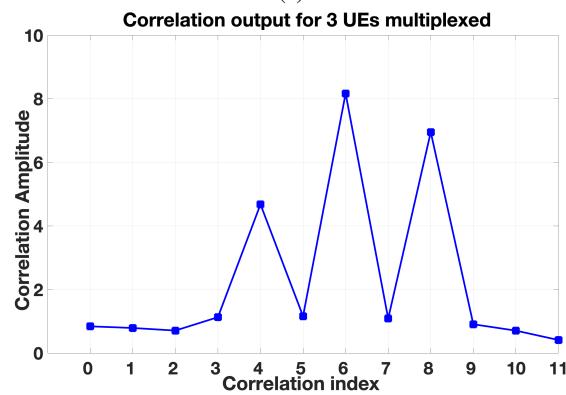
Resource Grid, where it occupies one Resource Block (RB)



$$\sum_{m=0}^{N_{UE}-1} h_m(k) e^{j\alpha_m k} \cdot \bar{r}_{u,v}(k) + w(k), \quad (3)$$



(a)



(b)

ples, predict the N_{UE} phase rotation values $\alpha_0, \alpha_1 \dots \alpha_{N_{UE}-1}$ (see Eq. (3)) applied to the base sequence. The obtained α values can then be mapped back to the UCI-specific cyclic shift m_{cs} for each UE by modulo 12 subtraction of the corresponding m_0 and n_{cs} which are provided by the higher

PUCCH ($N_{UE} = 0$), the NN prediction has to reflect this. In summary, the NN classifier has to predict either a single α value, multiple α values, or zero α values. Such a pattern of prediction is a typical use case of multi-label classification.

```
foreach  $u \in n_{UE}$  do
    |
    |
    |
    |   Transmit over channel
    |
    |
```

1) Simulated Datasets:

Using the MATLAB 5G Toolbox, (AWGN). For various SNR values (0, 5, 10, 15, and 20 dB), we

multi-hot encoded format.

A multi-channel 5G Remote Radio Head (RRH) with a dual-air (for the purpose of the paper, we utilize only one antenna with 100 MHz bandwidth. It is ORAN-compliant and follows the 7.2b split as defined in [17]. Other receiver components of the RRH include an in-house Low Noise Amplifier (LNA) with 60dB gain at the receiver front end and an ADRV 9009 RF transceiver. We place the transmitter antenna one meter away from the VSG through an antenna, over the air, and then



Fig. 3: IIT-Madras 5G testbed setup with the Remote Radio transmitter (Emulated UE).

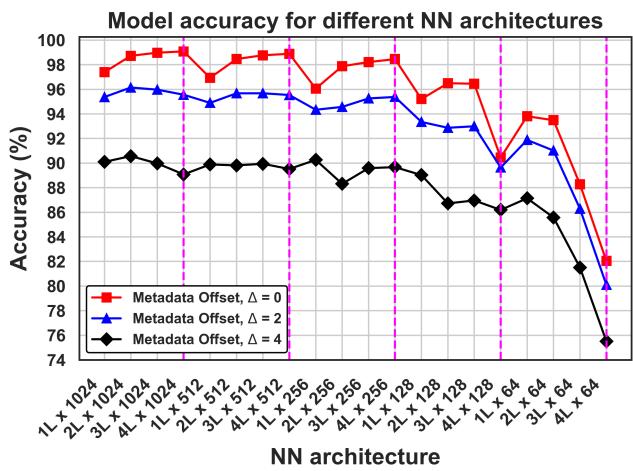
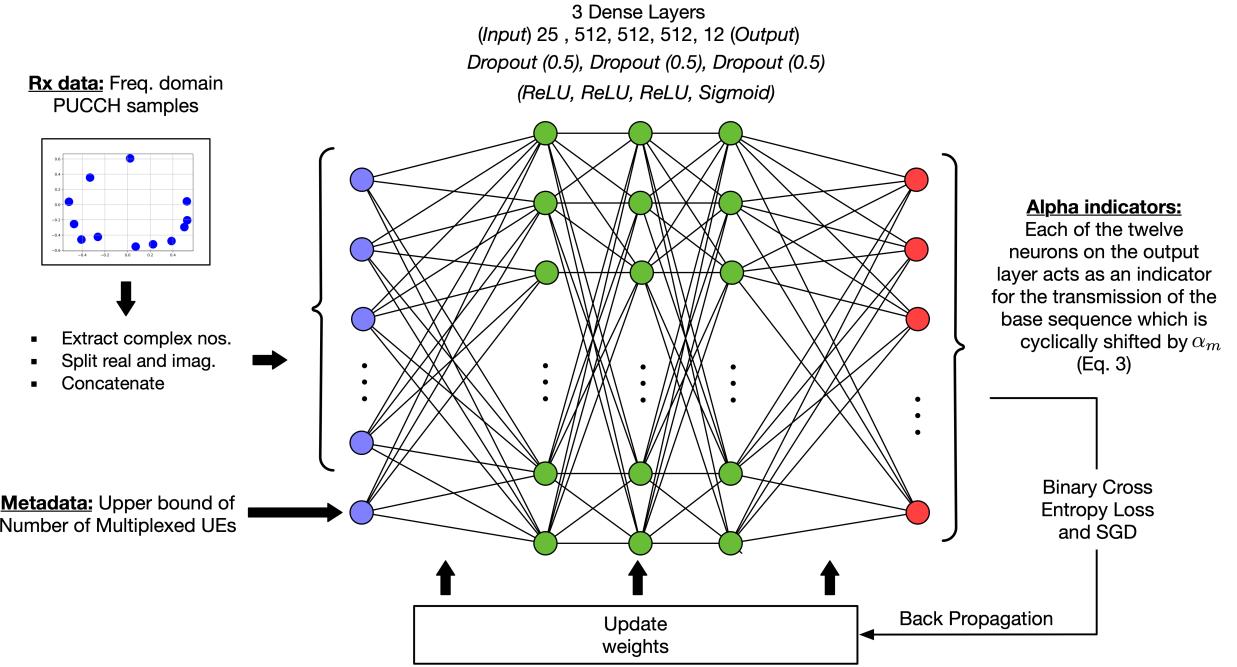
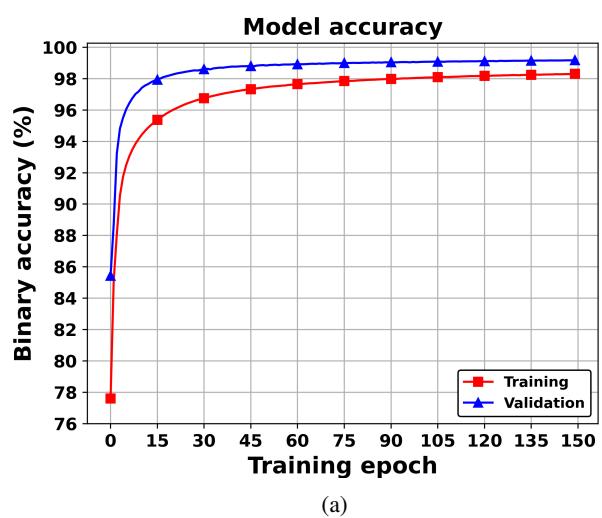
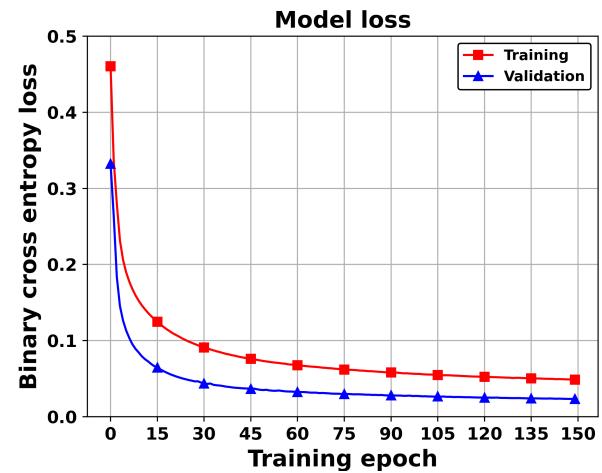


Fig. 5: Model accuracy for different FCN architectures at var-

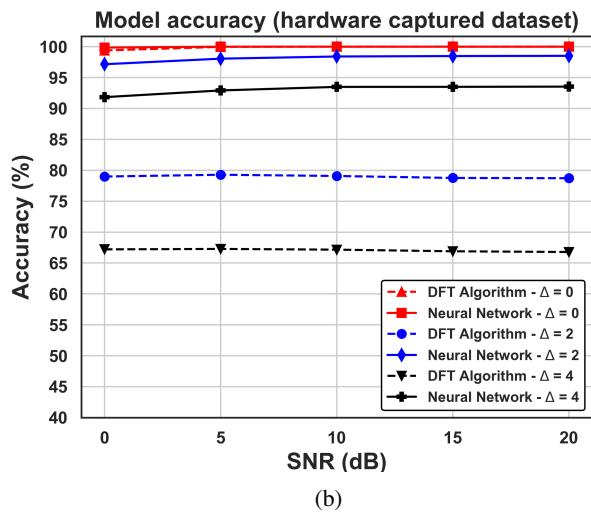
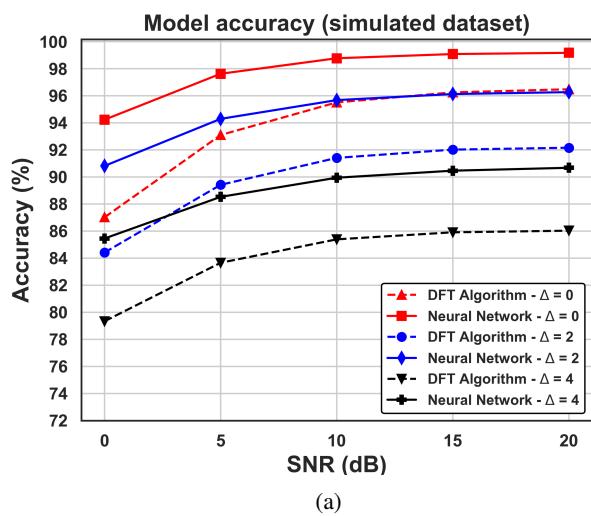


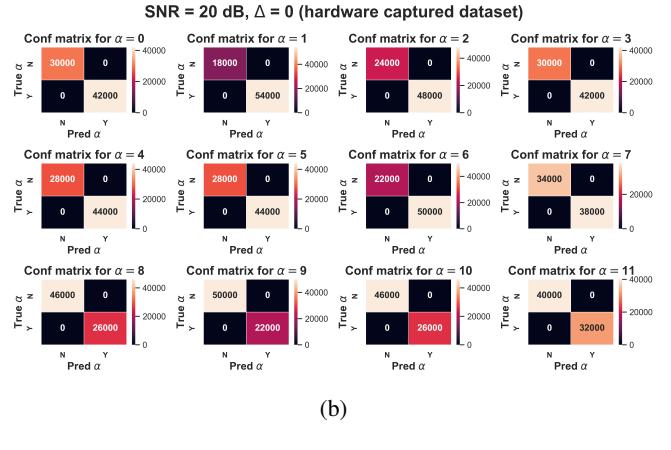
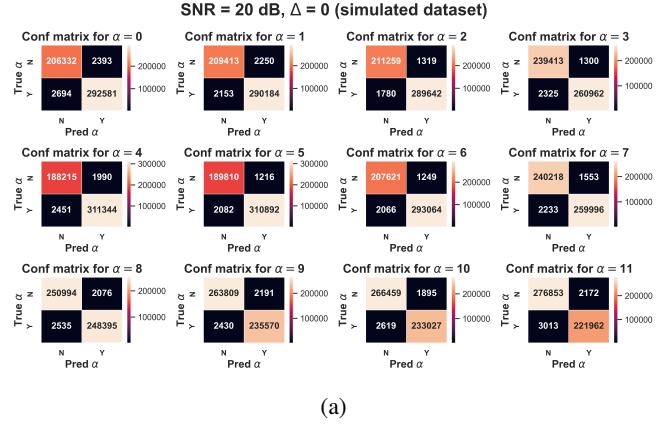
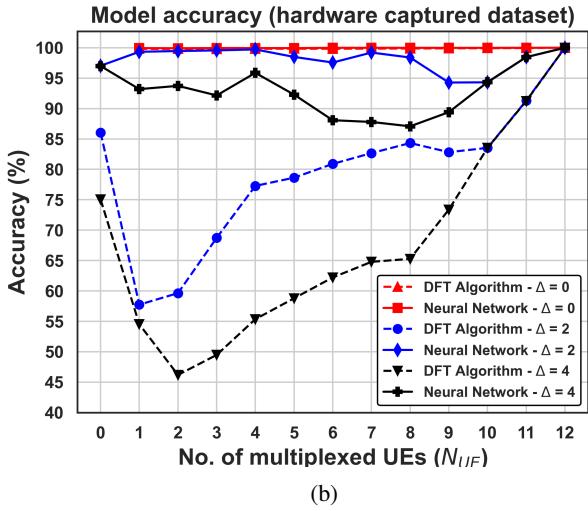
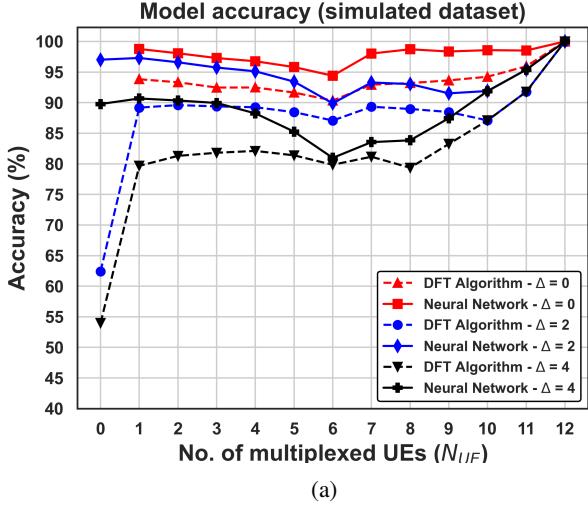
(a)



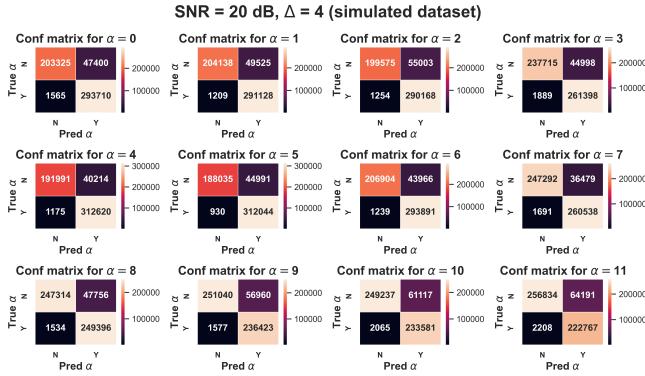
(b)

Fig. 6: Training was performed only using simulated data at

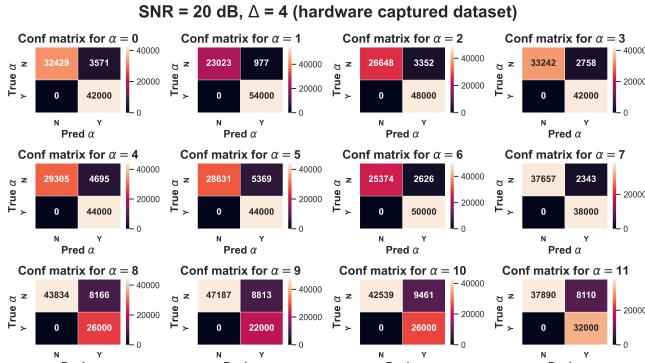




test dataset. Here, α represents the UCI specific cyclic shift.

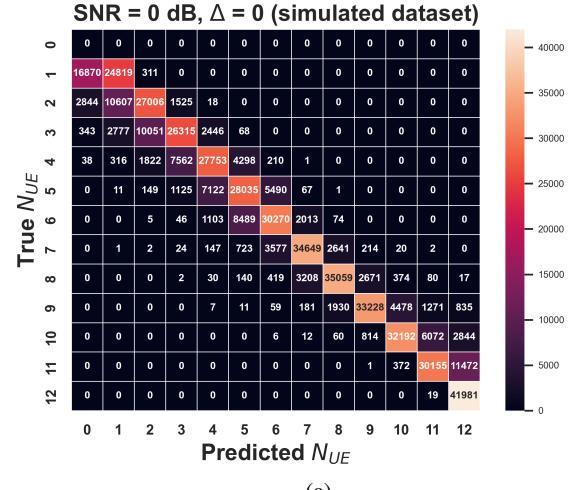


(a)

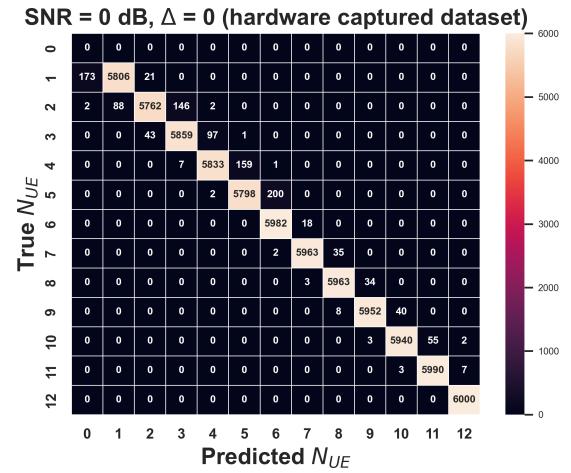


(b)

Fig. 10: Multi-label confusion matrix at SNR = 20 dB and $\Delta = 4$ for (a) simulated test dataset and (b) hardware captured



(a)

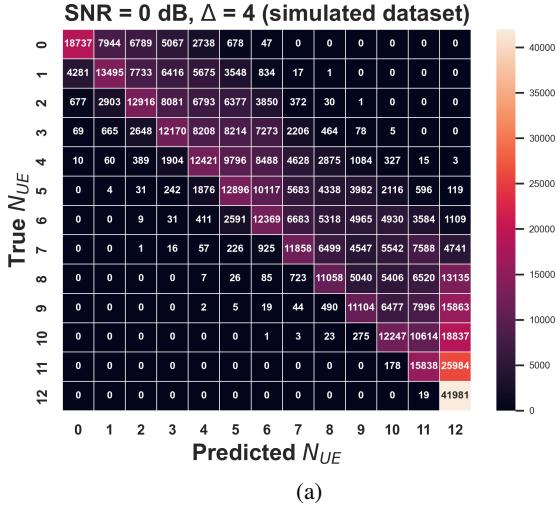


(b)

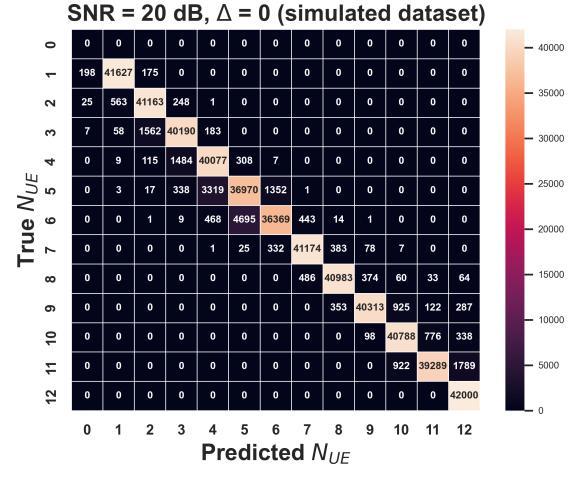
N_{UE} , at SNR = 0 dB and $\Delta = 0$ for (a) simulated test dataset

Status Report (BSR) [21]. No further uplink grants will be

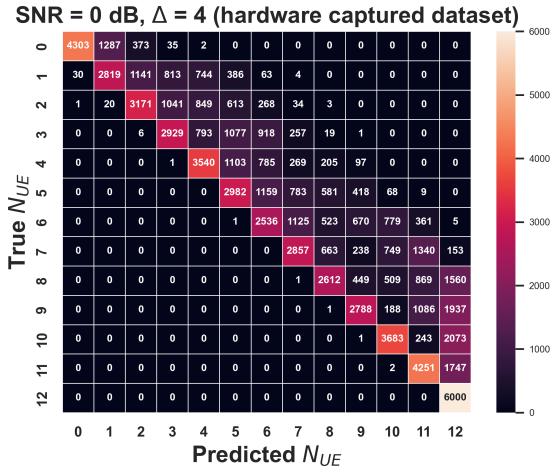
retransmission. Successive missed detection of ACKs will lead



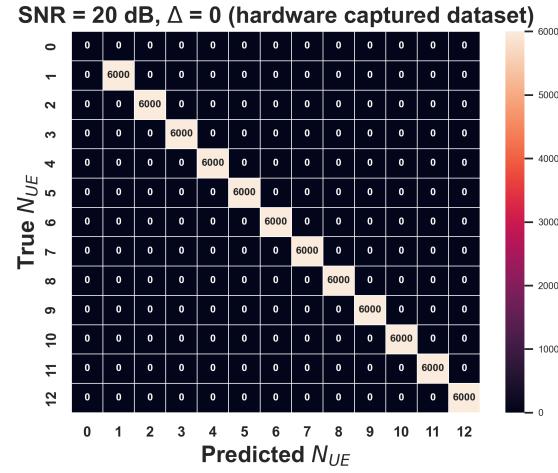
(a)



(a)



(b)



(b)

N_{UE} , at SNR = 0 dB and $\Delta = 4$ for (a) simulated test dataset

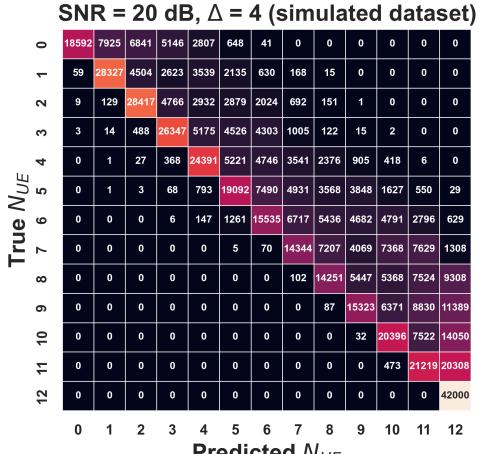
N_{UE} , at SNR = 20 dB and $\Delta = 0$ for (a) simulated test dataset

formance (Figure 5) and model complexity (Figure 17) must be

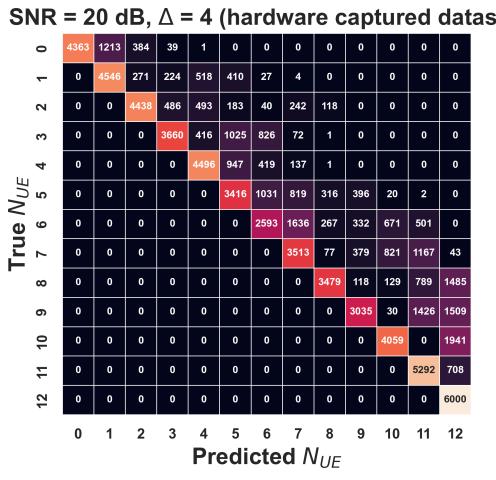
matrix multiplications efficiently.

CONCLUSION

the combinations of UCI bits across several multiplexed users. The proposed UCINet0 model is a multi-label classifier

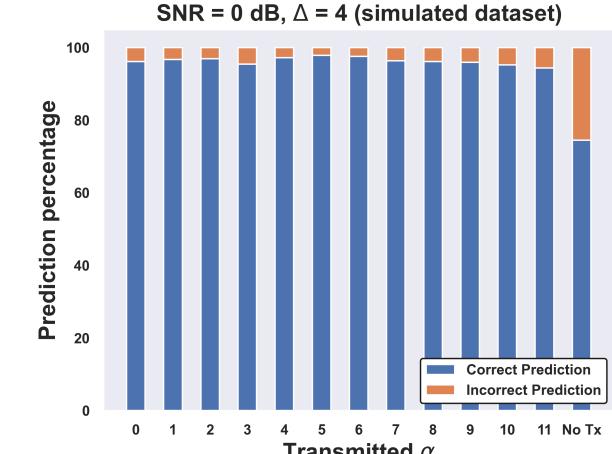


(a)

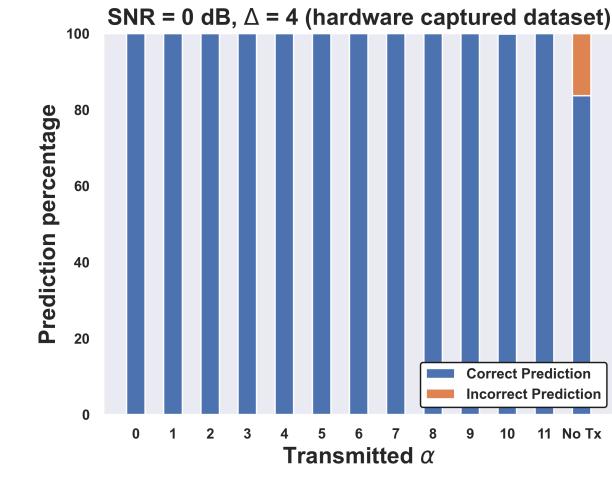


(b)

N_{UE} , at SNR = 20 dB and $\Delta = 4$ for (a) simulated test dataset



(a)



(b)

= 4, and with $N_{UE} = \{0, 1, 2, \dots, 12\}$ for (a) simulated test dataset and (b) hardware captured dataset.

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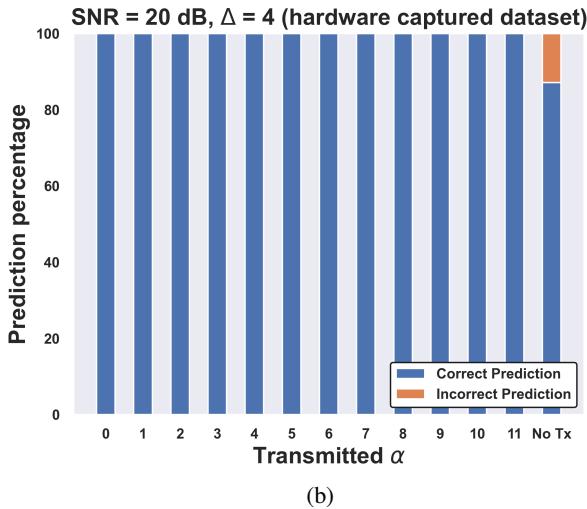
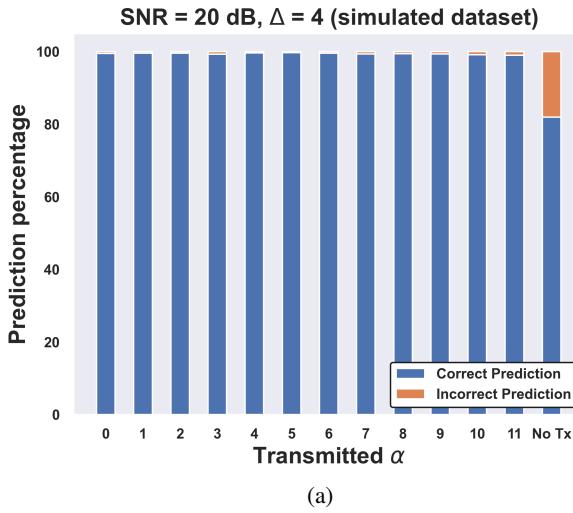
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range of scenarios. In addition to standard AI/ML metrics like

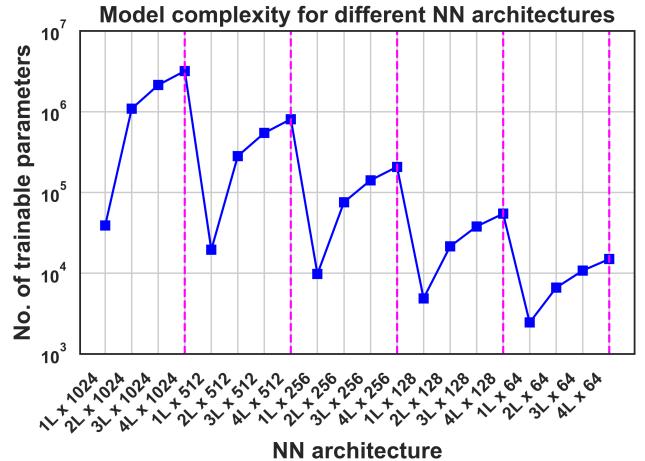
ACKNOWLEDGMENT

Beyond”.

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= 4, and with $N_{UE} = \{0, 1, 2, \dots, 12\}$ for (a) simulated test



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