Low Power Embedded Gesture Recognition Using Novel Short-Range Radar Sensors

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Human-computer interface (HCI) is an attractive scenario and a wide range of solutions, strategies, and technologies have been proposed recently. A very promising novel sensing technology is high frequency and short-range Doppler-radar. Previous works on Doppler-radar have achieved high accuracies on multiple different static, as well as dynamic hand-gestures [1]-[3]. In particular, the Soli system using short-range sensors developed at Google [4], in collaboration with Infineon, shows differentiation between "dynamic hand gestures" and "static hand postures". In particular, dynamic refers to the fact that the hand (or part of it) is in continuous motion during the gesture, while a static posture does not contain any movement. However, the proposed model in [4] uses more than 600MB of memory that is not matching the memory of low power microcontroller. Moreover, the Soli sensors are consuming more than 300mW of power that will drain the battery in a few minutes of use [6].

This work proposes a low-power high-accuracy embedded hand-gesture recognition using low power short-range radar sensors from Acconeer. The hardware and software match the requirements for battery-operated wearable devices. A 2D Convolutional Neural Network (CNN) using range frequency Doppler features is combined with a Temporal Convolutional Neural Network (TCN) for time sequence prediction. The final algorithm has a model size of only 45723 parameters, yielding a memory footprint of only 91kB. Two datasets containing 11 challenging hand gestures performed by 26 different people have been recorded containing a total of 20210 gesture instances. On the 11 hands, gestures and an accuracy of 87% (26 users) and 92% (single user) have been achieved. Furthermore, the prediction algorithm has been implemented in the GAP8 Parallel Ultra-Low-Power processor by GreenWaves Technologies, showing that live-prediction is feasible with only 21mW of power consumption for the full gesture prediction neural network

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References:

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[4] J. Lien, N. Gillian, M. E. Karagozler, P. Amihood, C. Schwesig, E. Olson, H. Raja, and I. Poupyrev, "Soli: Ubiquitous gesture sensing with millimeter wave radar," ACM Transactions on Graphics (TOG), vol. 35, no. 4, p. 142, 2016.

Figures and table

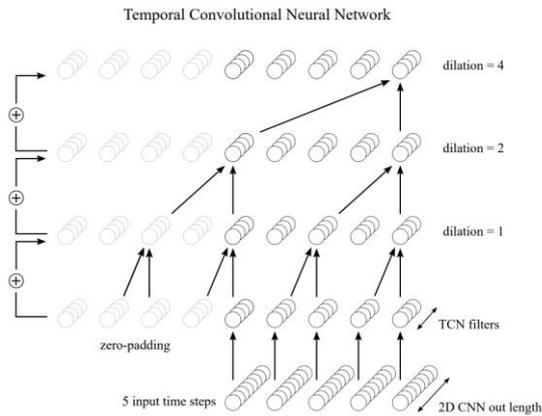Fig. 1.   The complete system used for recording and evaluation.

Fig. 2.   2D-CNN combine with TCN porposed in this work to achieve accuracy and energy efficiency.
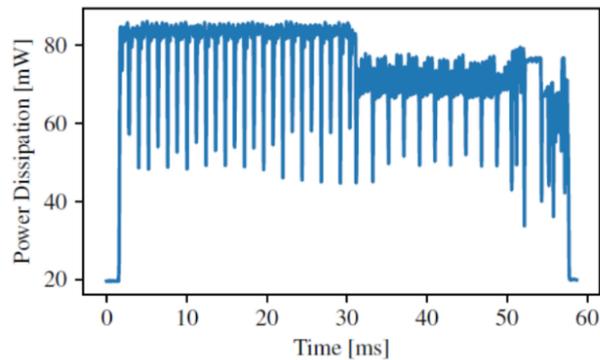

Fig. 3.   Measured power consumption of the proposed system during the processing and classification of a single gesture.

TABLE I.   PROPRIETARIES AND COMPARISON

Properties	Soli Error! Reference source not found.	This Work
Model Size	689MB	91kB
Dataset: Total Instances per Gesture	500	1610
Dataset: People	10	26
Embedded Implementation	No	Yes
Network Power Consumption	-	21mW
Sensor Power Consumption	300mW	<90mW
Accuracy Single-User	89.52%	92%
Accuracy MU- random Shuffle	81.52%	87.17%