

# Light Residual Network for Human Activity Recognition using Wearable Sensor Data

Francisco M. Calatrava-Nicolás<sup>1\*</sup>, Oscar Martinez Mozos<sup>1\*</sup>

<sup>1</sup>AI for Life, Centre for Applied Autonomous Sensor Systems, Örebro University, Fakultetsgatan 1, Örebro, Sweden

\*Member, IEEE

Index Terms—deep learning, human activity recognition, residual network, inertial sensors

## APPENDIX: LOOCV METRICS

This appendix presents further results on our proposed benchmark based on Leave-One(person)-Out Cross-Validation (LOOCV). Here we present further metrics for each Participant out and a global comparison. This information extends the results of Table 4 in the original paper.

The tables in this appendix show the results in terms of 4 metrics:

- Precision (P): It is defined as the number of true positives ( $T_p$ ) over the sum of true positives and false positives ( $F_p$ )

$$P = \frac{T_p}{T_p + F_p} \quad (1)$$

- Recall (R): It is defined as the number of true positives ( $T_p$ ) over the sum of true positive and false negatives ( $F_n$ )

$$R = \frac{T_p}{T_p + F_n} \quad (2)$$

- F1-Score: It is defined as the harmonic mean of precision and recall.

$$F1 - score = 2 \cdot \frac{P \cdot R}{P + R} \quad (3)$$

- F1-Score Average: It is the average of the F1-scores of all the classes.

$$F1 - score_{avg} = \frac{1}{N} \sum_{i=1}^N F1 - score_i \quad (4)$$

Where N is the number of classes.

- F1-Score Weighted: It is defined as the average of F1-scores of all the classes weighted by the number of instances in each class.

$$F1 - score_{Weighted} = \frac{1}{\sum_{i=1}^N w_i} \sum_{i=1}^N w_i \cdot F1 - score_i \quad (5)$$

Where  $w_i$  is the number of instances in the  $i$ th class and N the number of classes.

TABLE 1. LOOCV: Participant 1

Classes	Precision	Recall	F1-Score	Support
WA	1.0	1.0	1.0	95
WU	1.0	1.0	1.0	53
WD	1.0	1.0	1.0	49
SI	1.0	1.0	1.0	47
ST	1.0	1.0	1.0	53
LA	1.0	1.0	1.0	50

TABLE 2. LOOCV: Participant 2

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	59
WU	1.000	1.000	1.000	48
WD	1.000	1.000	1.000	47
SI	1.000	0.957	0.978	46
ST	0.964	1.000	0.982	54
LA	1.000	1.000	1.000	48

TABLE 3. LOOCV: Participant 3

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.00	58
WU	1.000	1.000	1.00	59
WD	1.000	1.000	1.00	49
SI	0.980	0.923	0.95	52
ST	0.938	0.984	0.96	61
LA	1.000	1.000	1.00	62

TABLE 4. LOOCV: Participant 4

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	60
WU	1.000	1.000	1.000	52
WD	1.000	1.000	1.000	45
SI	0.959	0.940	0.949	50
ST	0.947	0.964	0.956	56
LA	1.000	1.000	1.000	54

TABLE 5. LOOCV: Participant 5

Classes	Precision	Recall	F1-Score	Support
WA	1.000	0.929	0.963	56
WU	0.979	1.000	0.989	47
WD	1.000	1.000	1.000	47
SI	0.642	0.977	0.775	44
ST	0.972	0.625	0.761	56
LA	1.000	1.000	1.000	52

TABLE 6. LOOCV: Participant 6

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	57
WU	1.000	1.000	1.000	51
WD	1.000	1.000	1.000	48
SI	1.000	0.909	0.952	55
ST	0.919	1.000	0.958	57
LA	1.000	1.000	1.000	57

TABLE 7. LOOCV: Participant 7

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	57
WU	1.000	1.000	1.000	51
WD	1.000	1.000	1.000	47
SI	1.000	0.875	0.933	48
ST	0.898	1.000	0.946	53
LA	1.000	1.000	1.000	52

TABLE 8. LOOCV: Participant 8

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	48
WU	1.000	1.000	1.000	41
WD	1.000	1.000	1.000	38
SI	0.836	1.000	0.911	46
ST	1.000	0.833	0.909	54
LA	1.000	1.000	1.000	54

TABLE 9. LOOCV: Participant 9

Classes	Precision	Recall	F1-Score	Support
WA	0.963	1.000	0.981	52
WU	0.940	0.959	0.949	49
WD	1.000	1.000	1.000	42
SI	0.891	0.820	0.854	50
ST	0.870	0.889	0.879	45
LA	1.000	1.000	1.000	50

TABLE 10. LOOCV: Participant 10

Classes	Precision	Recall	F1-Score	Support
WA	0.840	0.792	0.816	53
WU	1.000	0.489	0.657	47
WD	0.585	1.000	0.738	38
SI	0.921	0.648	0.761	54
ST	0.683	0.932	0.788	44
LA	1.000	1.000	1.000	58

TABLE 11. LOOCV: Participant 11

Classes	Precision	Recall	F1-Score	Support
WA	1.0	1.0	1.0	59
WU	1.0	1.0	1.0	54
WD	1.0	1.0	1.0	46
SI	1.0	1.0	1.0	53
ST	1.0	1.0	1.0	47
LA	1.0	1.0	1.0	57

TABLE 12. LOOCV: Participant 12

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	50
WU	1.000	1.000	1.000	52
WD	1.000	1.000	1.000	46
SI	1.000	0.824	0.903	51
ST	0.871	1.000	0.931	61
LA	1.000	1.000	1.000	60

TABLE 13. LOOCV: Participant 13

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.00	1.000	57
WU	1.000	1.00	1.000	55
WD	1.000	1.00	1.000	47
SI	1.000	0.98	0.990	49
ST	0.983	1.00	0.991	57
LA	1.000	1.00	1.000	62

TABLE 14. LOOCV: Participant 14

Classes	Precision	Recall	F1-Score	Support
WA	0.000	0.000	0.000	59
WU	0.478	1.000	0.647	54
WD	1.000	1.000	1.000	45
SI	1.000	0.778	0.875	54
ST	0.833	1.000	0.909	60
LA	1.000	1.000	1.000	51

TABLE 15. LOOCV: Participant 15

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	54
WU	1.000	1.000	1.000	48
WD	1.000	1.000	1.000	42
SI	1.000	0.983	0.991	59
ST	0.981	1.000	0.991	53
LA	1.000	1.000	1.000	72

TABLE 16. LOOCV: Participant 16

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	51
WU	1.000	1.000	1.000	51
WD	1.000	1.000	1.000	47
SI	0.759	0.913	0.829	69
ST	0.906	0.744	0.817	78
LA	1.000	1.000	1.000	70

TABLE 17. LOOCV: Participant 17

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	61
WU	1.000	1.000	1.000	48
WD	1.000	1.000	1.000	46
SI	0.965	0.859	0.909	64
ST	0.894	0.974	0.933	78
LA	1.000	1.000	1.000	71

TABLE 18. LOOCV: Participant 18

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	56
WU	1.000	1.000	1.000	58
WD	1.000	1.000	1.000	55
SI	0.966	1.000	0.983	57
ST	1.000	0.973	0.986	73
LA	1.000	1.000	1.000	65

TABLE 19. LOOCV: Participant 19

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	52
WU	1.000	1.000	1.000	40
WD	1.000	1.000	1.000	39
SI	1.000	0.986	0.993	73
ST	1.000	1.000	1.000	73
LA	0.988	1.000	0.994	83

TABLE 20. LOOCV: Participant 20

Classes	Precision	Recall	F1-Score	Support
WA	1.0	1.0	1.0	51
WU	1.0	1.0	1.0	51
WD	1.0	1.0	1.0	45
SI	1.0	1.0	1.0	66
ST	1.0	1.0	1.0	73
LA	1.0	1.0	1.0	68

TABLE 21. LOOCV: Participant 21

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	52
WU	1.000	1.000	1.000	47
WD	1.000	1.000	1.000	45
SI	1.000	0.859	0.924	85
ST	0.881	1.000	0.937	89
LA	1.000	1.000	1.000	90

TABLE 22. LOOCV: Participant 22

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	46
WU	1.000	1.000	1.000	42
WD	1.000	1.000	1.000	36
SI	1.000	0.984	0.992	62
ST	0.984	1.000	0.992	63
LA	1.000	1.000	1.000	72

TABLE 23. LOOCV: Participant 23

Classes	Precision	Recall	F1-Score	Support
WA	1.00	1.000	1.000	59
WU	1.00	1.000	1.000	51
WD	1.00	1.000	1.000	54
SI	0.84	1.000	0.913	68
ST	1.00	0.809	0.894	68
LA	1.00	1.000	1.000	72

TABLE 24. LOOCV: Participant 24

Classes	Precision	Recall	F1-Score	Support
WA	1.0	1.0	1.0	58
WU	1.0	1.0	1.0	59
WD	1.0	1.0	1.0	55
SI	1.0	1.0	1.0	68
ST	1.0	1.0	1.0	69
LA	1.0	1.0	1.0	72

TABLE 25. LOOCV: Participant 25

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	74
WU	1.000	1.000	1.000	65
WD	1.000	0.966	0.982	58
SI	0.734	0.892	0.806	65
ST	0.887	0.743	0.809	74
LA	1.000	1.000	1.000	73

TABLE 26. LOOCV: Participant 26

Classes	Precision	Recall	F1-Score	Support
WA	1.0	1.0	1.0	59
WU	1.0	1.0	1.0	55
WD	1.0	1.0	1.0	50
SI	1.0	1.0	1.0	78
ST	1.0	1.0	1.0	74
LA	1.0	1.0	1.0	76

TABLE 27. LOOCV: Participant 27

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	57
WU	1.000	1.000	1.000	51
WD	1.000	1.000	1.000	44
SI	1.000	0.986	0.993	70
ST	0.988	1.000	0.994	80
LA	1.000	1.000	1.000	74

TABLE 28. LOOCV: Participant 28

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	54
WU	1.000	1.000	1.000	51
WD	1.000	1.000	1.000	46
SI	1.000	0.625	0.769	72
ST	0.745	1.000	0.854	79
LA	1.000	1.000	1.000	80

TABLE 29. LOOCV: Participant 29

Classes	Precision	Recall	F1-Score	Support
WA	1.000	1.000	1.000	53
WU	1.000	1.000	1.000	49
WD	1.000	1.000	1.000	48
SI	0.968	1.000	0.984	60
ST	1.000	0.969	0.984	65
LA	1.000	1.000	1.000	69

TABLE 30. LOOCV: Participant 30

Classes	Precision	Recall	F1-Score	Support
WA	1.0	1.0	1.0	65
WU	1.0	1.0	1.0	65
WD	1.0	1.0	1.0	62
SI	1.0	1.0	1.0	62
ST	1.0	1.0	1.0	59
LA	1.0	1.0	1.0	70

TABLE 31. LOOCV: Accuracy, F1-Score Average, F1-Score Weighted, and support.

Participant	Accuracy	F1-Score Average	F1-Score Weighted	Support
1	1.000	1.000	1.000	347
2	0.993	0.993	0.993	302
3	0.985	0.985	0.985	341
4	0.984	0.984	0.984	317
5	0.914	0.915	0.914	302
6	0.985	0.985	0.985	325
7	0.981	0.980	0.980	308
8	0.968	0.970	0.968	281
9	0.944	0.944	0.944	288
10	0.806	0.793	0.802	294
11	1.000	1.000	1.000	316
12	0.972	0.972	0.971	320
13	0.997	0.997	0.997	327
14	0.780	0.738	0.720	323
15	0.997	0.997	0.997	328
16	0.929	0.941	0.929	366
17	0.970	0.974	0.970	368
18	0.995	0.995	0.995	364
19	0.997	0.998	0.997	360
20	1.000	1.000	1.000	354
21	0.971	0.977	0.970	408
22	0.997	0.997	0.997	321
23	0.965	0.968	0.965	372
24	1.000	1.000	1.000	381
25	0.932	0.933	0.932	409
26	1.000	1.000	1.000	392
27	0.997	0.998	0.997	376
28	0.929	0.937	0.926	382
29	0.994	0.995	0.994	344
30	1.000	1.000	1.000	383
Average	0.966	0.966	0.964	-