

Digisport – digital transformation in sports

a case study about HAR based on IMU and RNN

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LS2N

Definition

digital transformation

the process of improving products, services and operations using digital technologies

digital transformation in sports

the process of improving individual and collective athletic performance using digital technologies

HAR human activity recognition

IMU inertial measurement unit

RNN recurrent neural network

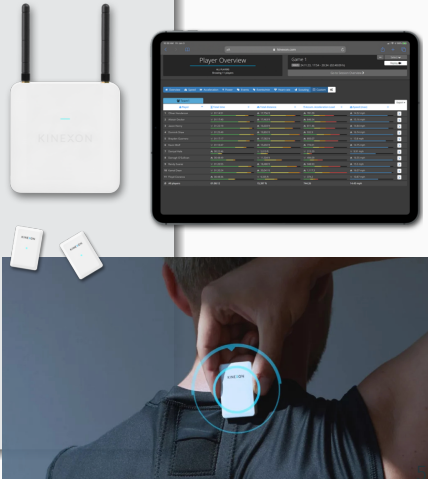
Introduction



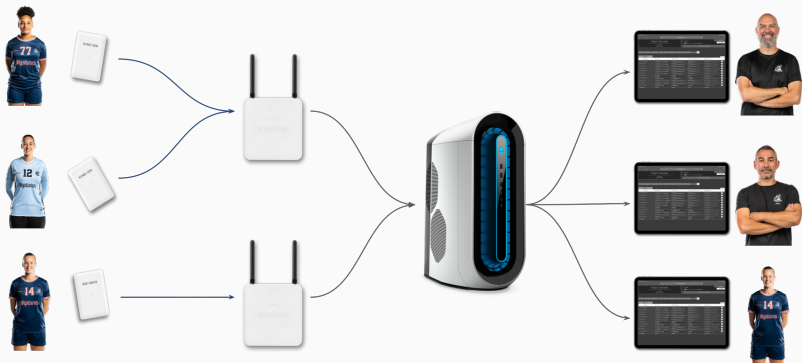
Needs and Requirements

monitoring external training load

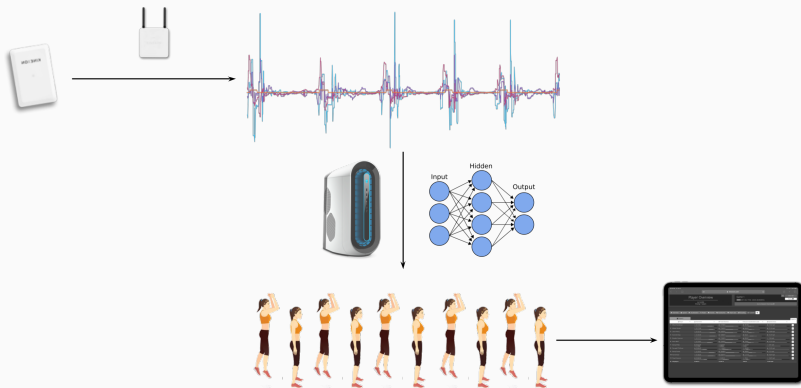
- indicators about runs
 - count
 - duration
 - speed
 - distance
 - type
 - direction
 - intensity
- indicators about jumps
 - count
 - height
- state-of-the-art
- low-cost
- custom-made



Hypothesis



Hypothesis



HAR based on IMU and RNN

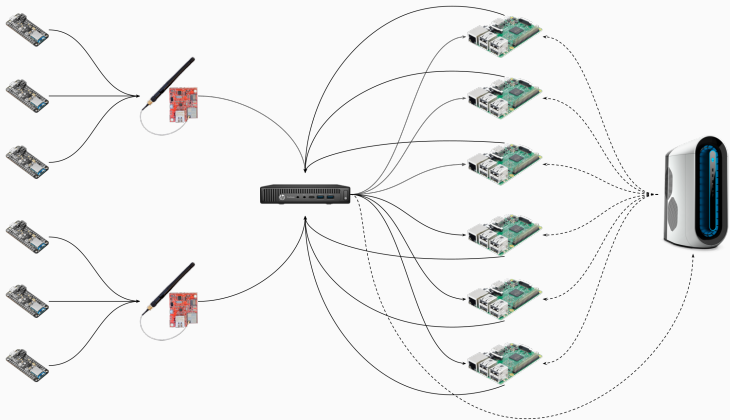
1. develop IMU components
 - low-cost: 400€ / athlete
2. build HAR datasets
 - custom-made: proof of concept
3. train RNN models
 - state-of-the-art: 0.99 accuracy
4. predict human activity
5. estimate activity features

HAR based on IMU and RNN

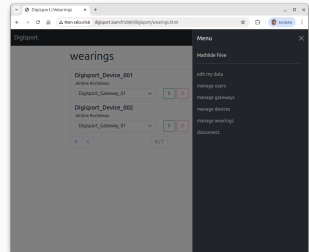
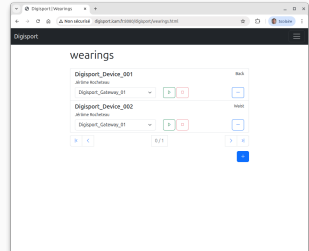
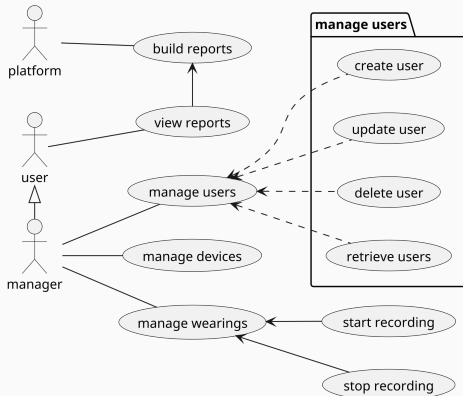
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Data Acquisition

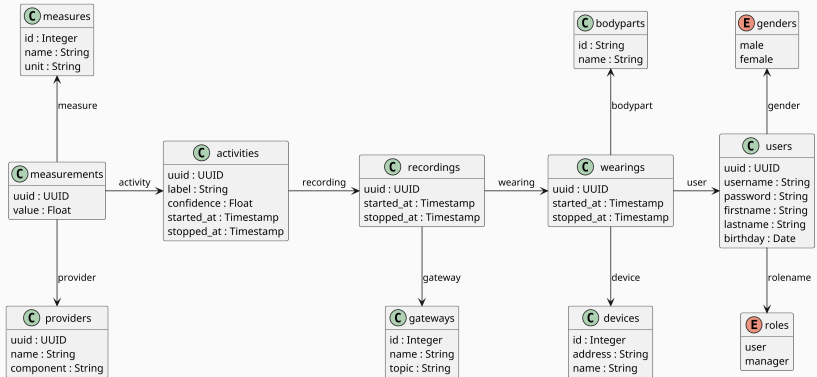
Architecture



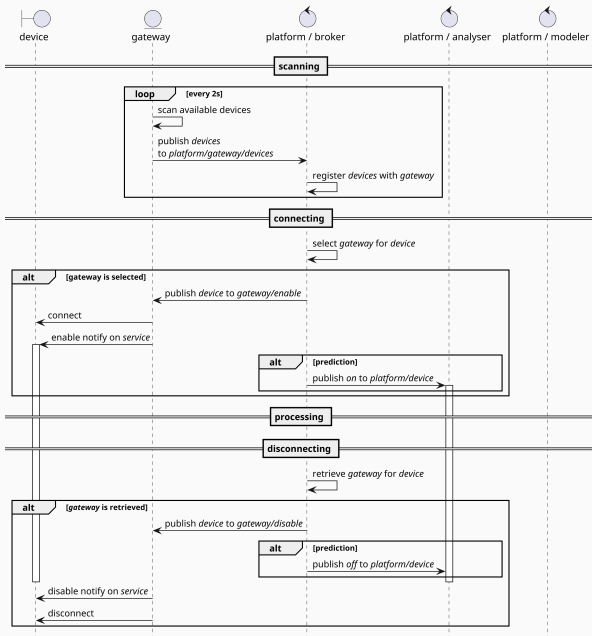
Use Cases



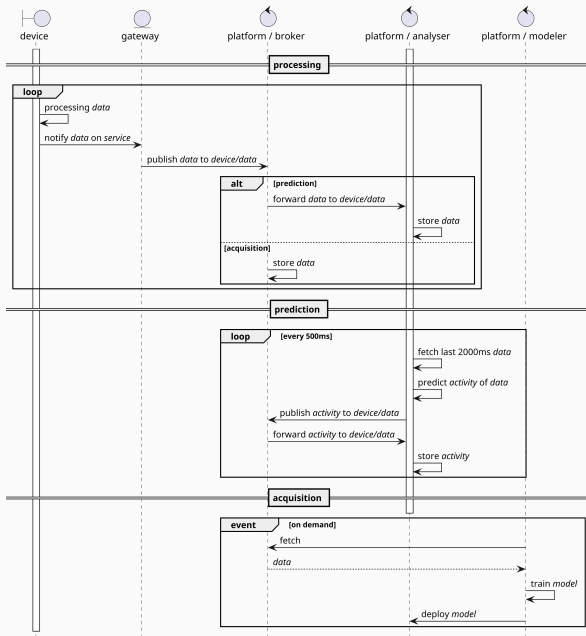
Classes



Sequences

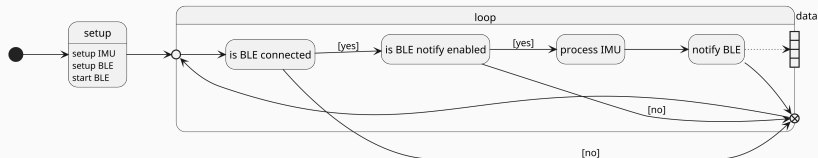


Sequences



Devices

Ⓢ data
float id : device identifier
float ax : x-axis acceleration
float ay : y-axis acceleration
float az : z-axis acceleration
float gx : x-axis angular velocity
float gy : y-axis angular velocity
float gz : z-axis angular velocity
float mx : x-axis magnetic flux density
float my : y-axis magnetic flux density
float mz : z-axis magnetic flux density
float t : device temperature
float v : battery voltage



$$\text{cost}(x) = 250x + 2400$$

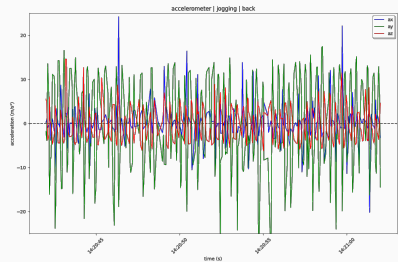
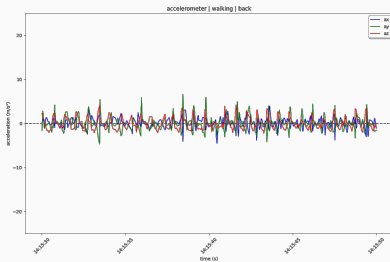
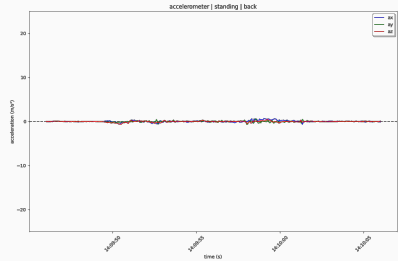
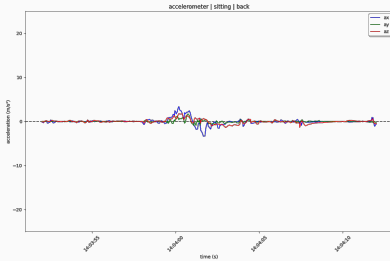
equipment	cost (€)	factor
device	80.00	x
gateway	30.00	$10x$
broker	2400.00	1
analyzer	140.00	x
modeler		1

Dataset Construction

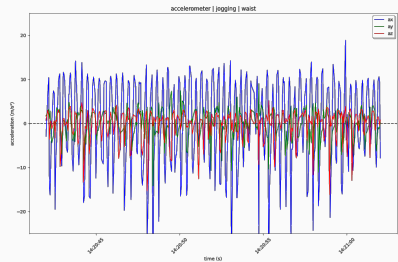
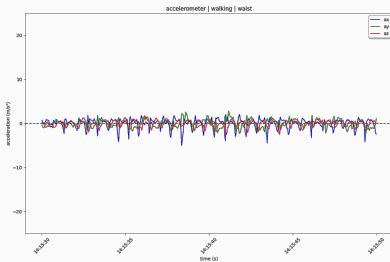
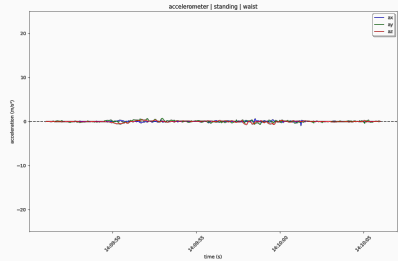
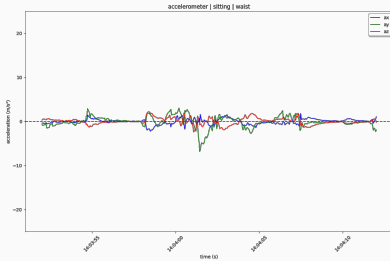
Sitting · Standing · Walking · Jogging

- 17 subjects
 - 7 women, 10 men
 - 4 – 9 subjects / session
- 2 body-parts
 - back, waist
- 3 sessions
 - 5mn / activity / session
 - all subjects at once
 - 8h 45mn recordings
 - 60Hz average frequency
 - 1 human annotator
- 4 datasets
 - 50Hz, 40Hz, 25Hz, 20Hz (20ms, 25ms, 40ms, 50ms)

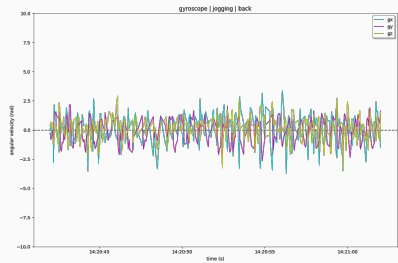
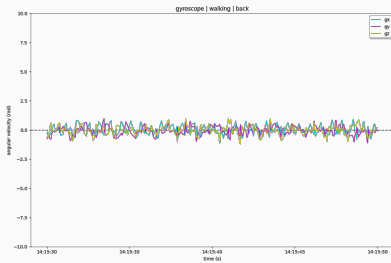
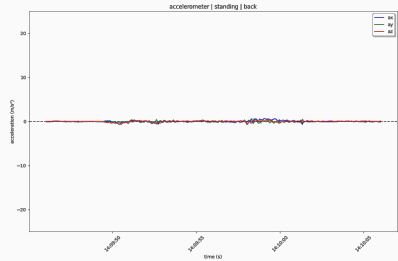
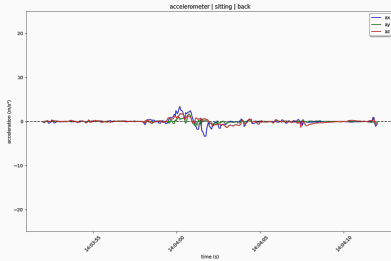
Accelerometer | Back



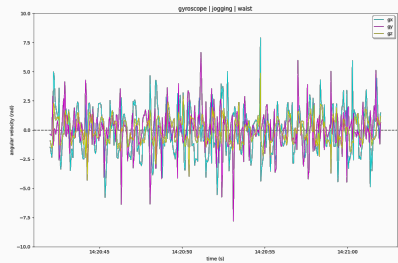
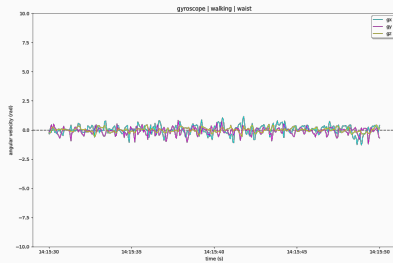
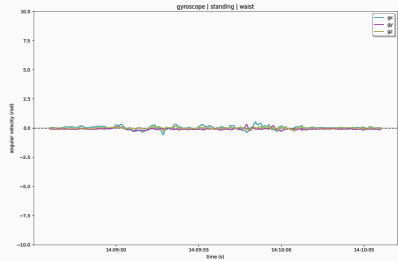
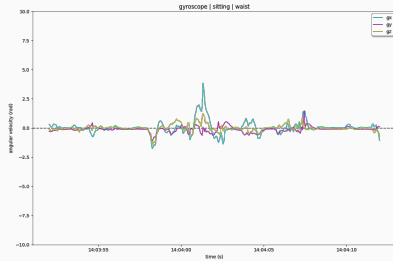
Accelerometer | Waist



Gyroscope | Back

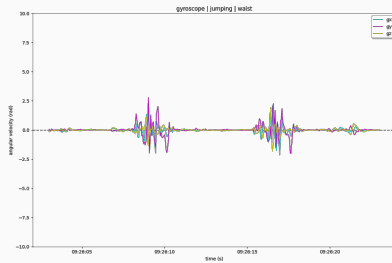
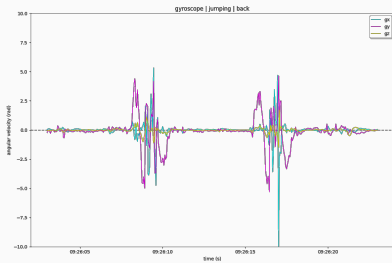
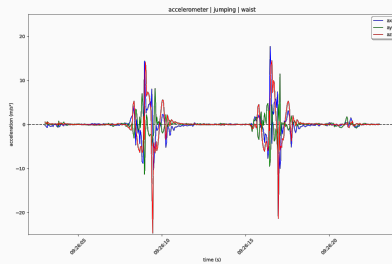
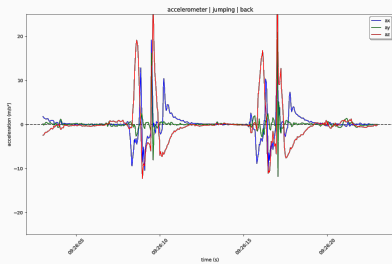


Gyroscope | Waist



Standing · Jumping

- 8 subjects
 - 6 women, 2 men
- 2 body-parts
 - back, waist
- 2 sessions
 - 5 series of 5 jumps with 5s standing in between
 - one subject at once
 - 42mn recordings
 - jumping: 8mn 50s
 - standing: 33mn 05s
 - 60Hz average frequency
 - 1 human annotator, jumping on signal
- 1 dataset
 - 50Hz (20ms)



Features, Labels, Sequences

ts	ax	ay	az	gx	gy	gz	s	j
09:26:16.820	5.657500	-1.042500	2.040000	-0.252244	0.681900	-0.166897	0.0	1.0
09:26:16.840	4.738750	-1.566250	0.806250	-0.088270	0.453611	0.023649	0.0	1.0
09:26:16.860	3.820000	-2.090000	-0.427500	0.075704	0.225322	0.214196	0.0	1.0
09:26:16.880	5.013333	-3.310000	-1.108333	-0.283587	-0.286467	0.132732	0.0	1.0
09:26:16.900	6.206667	-4.530000	-1.789167	-0.642877	-0.798255	0.051269	0.0	1.0
09:26:16.920	7.400000	-5.750000	-2.470000	-1.002168	-1.310044	-0.030194	0.0	1.0
09:26:16.940	-6.701250	-0.605000	-11.921250	-1.564230	-0.921512	-0.435154	0.0	1.0
09:26:16.960	-20.802500	4.540000	-21.372500	-2.126291	-0.532980	-0.840114	0.0	1.0
09:26:16.980	-15.958333	3.186667	-14.025833	-1.553387	-0.081041	-0.691936	0.0	1.0
09:26:17.000	-11.114167	1.833333	-6.679167	-0.980482	0.370897	-0.543757	0.0	1.0
09:26:17.020	-6.270000	0.480000	0.667500	-0.407578	0.822835	-0.395579	0.0	1.0
09:26:17.040	-8.152500	5.965000	-2.601250	0.136376	0.853117	-0.318653	0.0	1.0
09:26:17.060	-10.035000	11.450000	-5.870000	0.680329	0.883398	-0.241728	0.0	1.0
09:26:17.080	-9.152500	4.432500	-5.402500	1.180584	1.358390	-0.139539	0.0	1.0
09:26:17.100	-8.270000	-2.585000	-4.935000	1.680839	1.833381	-0.037350	0.0	1.0
09:26:17.120	-3.740000	-1.540000	-5.020000	1.021803	1.107062	-0.120340	0.0	1.0
09:26:17.140	-1.706250	-0.570000	-5.132500	0.639292	0.849386	-0.102407	0.0	1.0
09:26:17.160	0.327500	0.400000	-5.245000	0.256782	0.591710	-0.084474	0.0	1.0
09:26:17.180	-0.906250	0.340000	-4.232500	0.150033	0.494648	-0.153851	0.0	1.0
09:26:17.200	-2.140000	0.280000	-3.220000	0.043284	0.397586	-0.223228	0.2	0.8
09:26:17.220	-1.739167	0.235833	-3.318333	-0.014297	0.328791	-0.177558	0.4	0.6
09:26:17.240	-1.338333	0.191667	-3.416667	-0.071878	0.259996	-0.131889	0.6	0.4
09:26:17.260	-0.937500	0.147500	-3.515000	-0.129460	0.191201	-0.086219	0.8	0.2
09:26:17.280	-0.678750	0.060417	-3.025833	-0.202669	0.060607	-0.033394	1.0	0.0
09:26:17.300	-0.420000	-0.026667	-2.536667	-0.275878	-0.069988	0.019431	1.0	0.0
09:26:17.320	0.770000	0.540000	-0.470000	-0.388510	-0.308574	-0.056200	1.0	0.0
09:26:17.340	0.688750	0.481250	-0.135000	-0.385369	-0.325918	-0.054258	1.0	0.0
09:26:17.360	0.607500	0.422500	0.200000	-0.382227	-0.343263	-0.052316	1.0	0.0
09:26:17.380	0.620000	-0.021250	1.001250	-0.359560	-0.386394	-0.030107	1.0	0.0
09:26:17.400	0.632500	-0.465000	1.802500	-0.336892	-0.429526	-0.007898	1.0	0.0
09:26:17.420	0.795833	-0.329167	2.351667	-0.270322	-0.418908	-0.000989	1.0	0.0
09:26:17.440	0.959167	-0.193333	2.900833	-0.203753	-0.408291	0.005920	1.0	0.0
09:26:17.460	1.122500	-0.057500	3.450000	-0.137183	-0.397673	0.012828	1.0	0.0
09:26:17.480	1.610000	-0.345000	4.056250	-0.055043	-0.406356	0.021882	1.0	0.0
09:26:17.500	2.097500	-0.632500	4.662500	0.027096	-0.415039	0.030936	1.0	0.0

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09:26:17.100	-8.270000	-2.585000	-4.935000	1.680839	1.833381	-0.037350	0.0	1.0
09:26:17.120	-3.740000	-1.540000	-5.020000	1.021803	1.107062	-0.120340	0.0	1.0
09:26:17.140	-1.706250	-0.570000	-5.132500	0.639292	0.849386	-0.102407	0.0	1.0
09:26:17.160	0.327500	0.400000	-5.245000	0.256782	0.591710	-0.084474	0.0	1.0
09:26:17.180	-0.906250	0.340000	-4.232500	0.150033	0.494648	-0.153851	0.0	1.0
09:26:17.200	-2.140000	0.280000	-3.220000	0.043284	0.397586	-0.223228	0.2	0.8
09:26:17.220	-1.739167	0.235833	-3.318333	-0.014297	0.328791	-0.177558	0.4	0.6
09:26:17.240	-1.338333	0.191667	-3.416667	-0.071878	0.259996	-0.131889	0.6	0.4
09:26:17.260	-0.937500	0.147500	-3.515000	-0.129460	0.191201	-0.086219	0.8	0.2
09:26:17.280	-0.678750	0.060417	-3.025833	-0.202669	0.060607	-0.033394	1.0	0.0
09:26:17.300	-0.420000	-0.026667	-2.536667	-0.275878	-0.069988	0.019431	1.0	0.0
09:26:17.320	0.770000	0.540000	-0.470000	-0.388510	-0.308574	-0.056200	1.0	0.0
09:26:17.340	0.688750	0.481250	-0.135000	-0.385369	-0.325918	-0.054258	1.0	0.0
09:26:17.360	0.607500	0.422500	0.200000	-0.382227	-0.343263	-0.052316	1.0	0.0
09:26:17.380	0.620000	-0.021250	1.001250	-0.359560	-0.386394	-0.030107	1.0	0.0
09:26:17.400	0.632500	-0.465000	1.802500	-0.336892	-0.429526	-0.007898	1.0	0.0
09:26:17.420	0.795833	-0.329167	2.351667	-0.270322	-0.418908	-0.000989	1.0	0.0
09:26:17.440	0.959167	-0.193333	2.900833	-0.203753	-0.408291	0.005920	1.0	0.0
09:26:17.460	1.122500	-0.057500	3.450000	-0.137183	-0.397673	0.012828	1.0	0.0
09:26:17.480	1.610000	-0.345000	4.056250	-0.055043	-0.406356	0.021882	1.0	0.0
09:26:17.500	2.097500	-0.632500	4.662500	0.027096	-0.415039	0.030936	1.0	0.0

Features, Labels, Sequences

ts	ax	ay	az	gx	gy	gz	s	j
09:26:16.820	5.657500	-1.042500	2.040000	-0.252244	0.681900	-0.166897	0.0	1.0
09:26:16.840	4.738750	-1.566250	0.806250	-0.088270	0.453611	0.023649	0.0	1.0
09:26:16.860	3.820000	-2.090000	-0.427500	0.075704	0.225322	0.214196	0.0	1.0
09:26:16.880	5.013333	-3.310000	-1.108333	-0.283587	-0.286467	0.132732	0.0	1.0
09:26:16.900	6.206667	-4.530000	-1.789167	-0.642877	-0.798255	0.051269	0.0	1.0
09:26:16.920	7.400000	-5.750000	-2.470000	-1.002168	-1.310044	-0.030194	0.0	1.0
09:26:16.940	-6.701250	-0.605000	-11.921250	-1.564230	-0.921512	-0.435154	0.0	1.0
09:26:16.960	-20.802500	4.540000	-21.372500	-2.126291	-0.532980	-0.840114	0.0	1.0
09:26:16.980	-15.958333	3.186667	-14.025833	-1.553387	-0.081041	-0.691936	0.0	1.0
09:26:17.000	-11.1114167	1.833333	-6.679167	-0.980482	0.370897	-0.543757	0.0	1.0
09:26:17.020	-6.270000	0.480000	0.667500	-0.407578	0.822835	-0.395579	0.0	1.0
09:26:17.040	-8.152500	5.965000	-2.601250	0.136376	0.853117	-0.318653	0.0	1.0
09:26:17.060	-10.035000	11.450000	-5.870000	0.680329	0.883398	-0.241728	0.0	1.0
09:26:17.080	-9.152500	4.432500	-5.402500	1.180584	1.358390	-0.139539	0.0	1.0
09:26:17.100	-8.270000	-2.585000	-4.935000	1.680839	1.833381	-0.037350	0.0	1.0
09:26:17.120	-3.740000	-1.540000	-5.020000	1.021803	1.107062	-0.120340	0.0	1.0
09:26:17.140	-1.706250	-0.570000	-5.132500	0.639292	0.849386	-0.102407	0.0	1.0
09:26:17.160	0.327500	0.400000	-5.245000	0.256782	0.591710	-0.084474	0.0	1.0
09:26:17.180	-0.906250	0.340000	-4.232500	0.150033	0.494648	-0.153851	0.0	1.0
09:26:17.200	-2.140000	0.280000	-3.220000	0.043284	0.397586	-0.223228	0.2	0.8
09:26:17.220	-1.739167	0.235833	-3.318333	-0.014297	0.328791	-0.177558	0.4	0.6
09:26:17.240	-1.338333	0.191667	-3.416667	-0.071878	0.259996	-0.131889	0.6	0.4
09:26:17.260	-0.937500	0.147500	-3.515000	-0.129460	0.191201	-0.086219	0.8	0.2
09:26:17.280	-0.678750	0.060417	-3.025833	-0.202669	0.060607	-0.033394	1.0	0.0
09:26:17.300	-0.420000	-0.026667	-2.536667	-0.275878	-0.069988	0.019431	1.0	0.0
09:26:17.320	0.770000	0.540000	-0.470000	-0.388510	-0.308574	-0.056200	1.0	0.0
09:26:17.340	0.688750	0.481250	-0.135000	-0.385369	-0.325918	-0.054258	1.0	0.0
09:26:17.360	0.607500	0.422500	0.200000	-0.382227	-0.343263	-0.052316	1.0	0.0
09:26:17.380	0.620000	-0.021250	1.001250	-0.359560	-0.386394	-0.030107	1.0	0.0
09:26:17.400	0.632500	-0.465000	1.802500	-0.336892	-0.429526	-0.007898	1.0	0.0
09:26:17.420	0.795833	-0.329167	2.351667	-0.270322	-0.418908	-0.000989	1.0	0.0
09:26:17.440	0.959167	-0.193333	2.900833	-0.203753	-0.408291	0.005920	1.0	0.0
09:26:17.460	1.122500	-0.057500	3.450000	-0.137183	-0.397673	0.012828	1.0	0.0
09:26:17.480	1.610000	-0.345000	4.056250	-0.055043	-0.406356	0.021882	1.0	0.0
09:26:17.500	2.097500	-0.632500	4.662500	0.027096	-0.415039	0.030936	1.0	0.0

Features, Labels, Sequences

ts	ax	ay	az	gx	gy	gz	s	j
09:26:16.820	5.657500	-1.042500	2.040000	-0.252244	0.681900	-0.166897	0.0	1.0
09:26:16.840	4.738750	-1.566250	0.806250	-0.088270	0.453611	0.023649	0.0	1.0
09:26:16.860	3.820000	-2.090000	-0.427500	0.075704	0.225322	0.214196	0.0	1.0
09:26:16.880	5.013333	-3.310000	-1.108333	-0.283587	-0.286467	0.132732	0.0	1.0
09:26:16.900	6.206667	-4.530000	-1.789167	-0.642877	-0.798255	0.051269	0.0	1.0
09:26:16.920	7.400000	-5.750000	-2.470000	-1.002168	-1.310044	-0.030194	0.0	1.0
09:26:16.940	-6.701250	-0.605000	-11.921250	-1.564230	-0.921512	-0.435154	0.0	1.0
09:26:16.960	-20.802500	4.540000	-21.372500	-2.126291	-0.532980	-0.840114	0.0	1.0
09:26:16.980	-15.958333	3.186667	-14.025833	-1.553387	-0.081041	-0.691936	0.0	1.0
09:26:17.000	-11.114167	1.833333	-6.679167	-0.980482	0.370897	-0.543757	0.0	1.0
09:26:17.020	-6.270000	0.480000	0.667500	-0.407578	0.822835	-0.395579	0.0	1.0
09:26:17.040	-8.152500	5.965000	-2.601250	0.136376	0.853117	-0.318653	0.0	1.0
09:26:17.060	-10.035000	11.450000	-5.870000	0.680329	0.883398	-0.241728	0.0	1.0
09:26:17.080	-9.152500	4.432500	-5.402500	1.180584	1.358390	-0.139539	0.0	1.0
09:26:17.100	-8.270000	-2.585000	-4.935000	1.680839	1.833381	-0.037350	0.0	1.0
09:26:17.120	-3.740000	-1.540000	-5.020000	1.021803	1.107062	-0.120340	0.0	1.0
09:26:17.140	-1.706250	-0.570000	-5.132500	0.639292	0.849386	-0.102407	0.0	1.0
09:26:17.160	0.327500	0.400000	-5.245000	0.256782	0.591710	-0.084474	0.0	1.0
09:26:17.180	-0.906250	0.340000	-4.232500	0.150033	0.494648	-0.153851	0.0	1.0
09:26:17.200	-2.140000	0.280000	-3.220000	0.043284	0.397586	-0.223228	0.2	0.8
09:26:17.220	-1.739167	0.235833	-3.318333	-0.014297	0.328791	-0.177558	0.4	0.6
09:26:17.240	-1.338333	0.191667	-3.416667	-0.071878	0.259996	-0.131889	0.6	0.4
09:26:17.260	-0.937500	0.147500	-3.515000	-0.129460	0.191201	-0.086219	0.8	0.2
09:26:17.280	-0.678750	0.060417	-3.025833	-0.202669	0.060607	-0.033394	1.0	0.0
09:26:17.300	-0.420000	-0.026667	-2.536667	-0.275878	-0.069988	0.019431	1.0	0.0
09:26:17.320	0.770000	0.540000	-0.470000	-0.388510	-0.308574	-0.056200	1.0	0.0
09:26:17.340	0.688750	0.481250	-0.135000	-0.385369	-0.325918	-0.054258	1.0	0.0
09:26:17.360	0.607500	0.422500	0.200000	-0.382227	-0.343263	-0.052316	1.0	0.0
09:26:17.380	0.620000	-0.021250	1.001250	-0.359560	-0.386394	-0.030107	1.0	0.0
09:26:17.400	0.632500	-0.465000	1.802500	-0.336892	-0.429526	-0.007898	1.0	0.0
09:26:17.420	0.795833	-0.329167	2.351667	-0.270322	-0.418908	-0.000989	1.0	0.0
09:26:17.440	0.959167	-0.193333	2.900833	-0.203753	-0.408291	0.005920	1.0	0.0
09:26:17.460	1.122500	-0.057500	3.450000	-0.137183	-0.397673	0.012828	1.0	0.0
09:26:17.480	1.610000	-0.345000	4.056250	-0.055043	-0.406356	0.021882	1.0	0.0
09:26:17.500	2.097500	-0.632500	4.662500	0.027096	-0.415039	0.030936	1.0	0.0

Features, Labels, Sequences

ts	ax	ay	az	gx	gy	gz	s	j
09:26:16.820	5.657500	-1.042500	2.040000	-0.252244	0.681900	-0.166897	0.0	1.0
09:26:16.840	4.738750	-1.566250	0.806250	-0.088270	0.453611	0.023649	0.0	1.0
09:26:16.860	3.820000	-2.090000	-0.427500	0.075704	0.225322	0.214196	0.0	1.0
09:26:16.880	5.013333	-3.310000	-1.108333	-0.283587	-0.286467	0.132732	0.0	1.0
09:26:16.900	6.206667	-4.530000	-1.789167	-0.642877	-0.798255	0.051269	0.0	1.0
09:26:16.920	7.400000	-5.750000	-2.470000	-1.002168	-1.310044	-0.030194	0.0	1.0
09:26:16.940	-6.701250	-0.605000	-11.921250	-1.564230	-0.921512	-0.435154	0.0	1.0
09:26:16.960	-20.802500	4.540000	-21.372500	-2.126291	-0.532980	-0.840114	0.0	1.0
09:26:16.980	-15.958333	3.186667	-14.025833	-1.553387	-0.081041	-0.691936	0.0	1.0
09:26:17.000	-11.114167	1.833333	-6.679167	-0.980482	0.370897	-0.543757	0.0	1.0
09:26:17.020	-6.270000	0.480000	0.667500	-0.407578	0.822835	-0.395579	0.0	1.0
09:26:17.040	-8.152500	5.965000	-2.601250	0.136376	0.853117	-0.318653	0.0	1.0
09:26:17.060	-10.035000	11.450000	-5.870000	0.680329	0.883398	-0.241728	0.0	1.0
09:26:17.080	-9.152500	4.432500	-5.402500	1.180584	1.358390	-0.139539	0.0	1.0
09:26:17.100	-8.270000	-2.585000	-4.935000	1.680839	1.833381	-0.037350	0.0	1.0
09:26:17.120	-3.740000	-1.540000	-5.020000	1.021803	1.107062	-0.120340	0.0	1.0
09:26:17.140	-1.706250	-0.570000	-5.132500	0.639292	0.849386	-0.102407	0.0	1.0
09:26:17.160	0.327500	0.400000	-5.245000	0.256782	0.591710	-0.084474	0.0	1.0
09:26:17.180	-0.906250	0.340000	-4.232500	0.150033	0.494648	-0.153851	0.0	1.0
09:26:17.200	-2.140000	0.280000	-3.220000	0.043284	0.397586	-0.223228	0.2	0.8
09:26:17.220	-1.739167	0.235833	-3.318333	-0.014297	0.328791	-0.177558	0.4	0.6
09:26:17.240	-1.338333	0.191667	-3.416667	-0.071878	0.259996	-0.131889	0.6	0.4
09:26:17.260	-0.937500	0.147500	-3.515000	-0.129460	0.191201	-0.086219	0.8	0.2
09:26:17.280	-0.678750	0.060417	-3.025833	-0.202669	0.060607	-0.033394	1.0	0.0
09:26:17.300	-0.420000	-0.026667	-2.536667	-0.275878	-0.069988	0.019431	1.0	0.0
09:26:17.320	0.770000	0.540000	-0.470000	-0.388510	-0.308574	-0.056200	1.0	0.0
09:26:17.340	0.688750	0.481250	-0.135000	-0.385369	-0.325918	-0.054258	1.0	0.0
09:26:17.360	0.607500	0.422500	0.200000	-0.382227	-0.343263	-0.052316	1.0	0.0
09:26:17.380	0.620000	-0.021250	1.001250	-0.359560	-0.386394	-0.030107	1.0	0.0
09:26:17.400	0.632500	-0.465000	1.802500	-0.336892	-0.429526	-0.007898	1.0	0.0
09:26:17.420	0.795833	-0.329167	2.351667	-0.270322	-0.418908	-0.000989	1.0	0.0
09:26:17.440	0.959167	-0.193333	2.900833	-0.203753	-0.408291	0.005920	1.0	0.0
09:26:17.460	1.122500	-0.057500	3.450000	-0.137183	-0.397673	0.012828	1.0	0.0
09:26:17.480	1.610000	-0.345000	4.056250	-0.055043	-0.406356	0.021882	1.0	0.0
09:26:17.500	2.097500	-0.632500	4.662500	0.027096	-0.415039	0.030936	1.0	0.0

Model Training and Evaluation

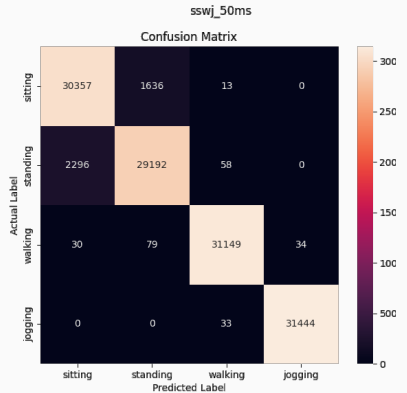
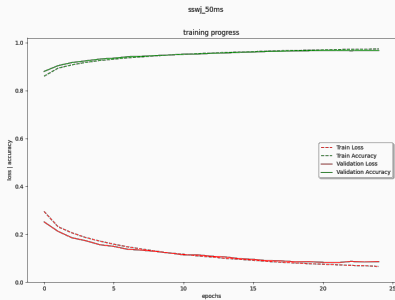
Modeling

```
def model():  
    model = Sequential()  
    model.add(Conv1D(12, 1, input_shape=(100, 6)))  
    model.add(Conv1D(12, 1, input_shape=(100, 6)))  
    model.add(MaxPooling1D(pool_size=3))  
    model.add(LSTM(120, input_shape=(100, 6), return_sequences=True))  
    model.add(Dropout(0.4))  
    model.add(LSTM(60, input_shape=(100, 6), return_sequences=False))  
    model.add(Dropout(0.2))  
    model.add(Flatten())  
    model.add(Dense(40, activation='relu'))  
    model.add(Dense(5, activation='softmax'))  
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])  
    return model
```

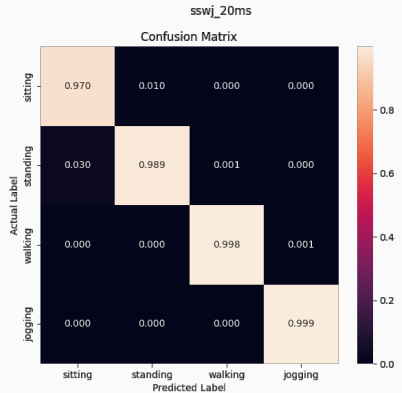
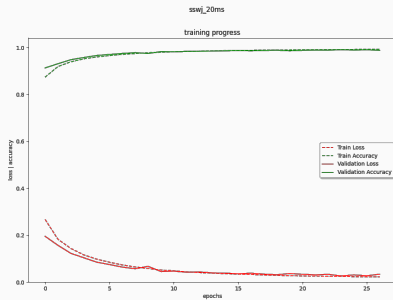
window length = 2000 ms

window offset = 500 ms

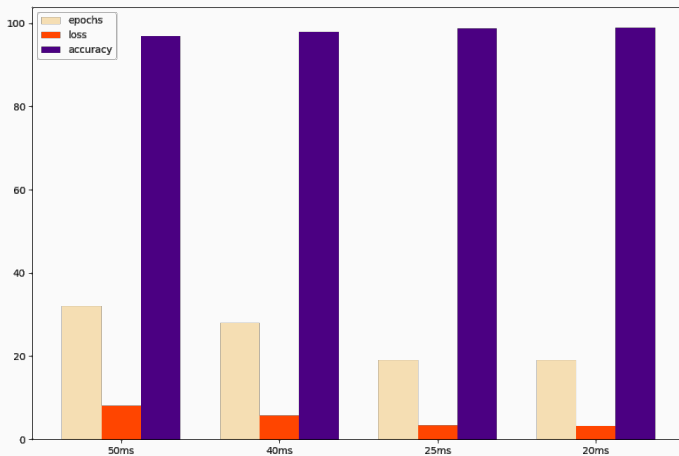
sampling rate = 20 ms



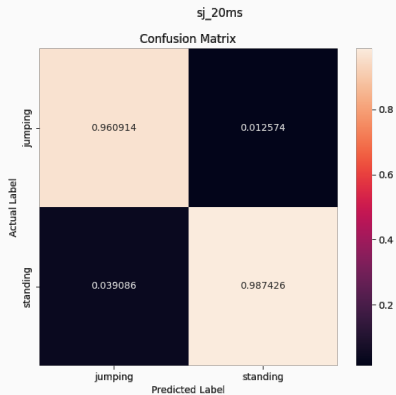
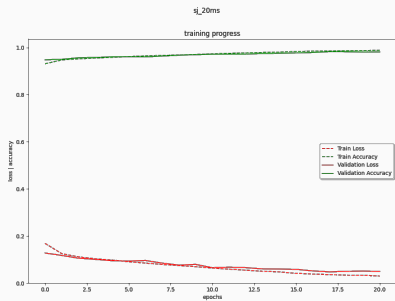
SSWJ 50Hz

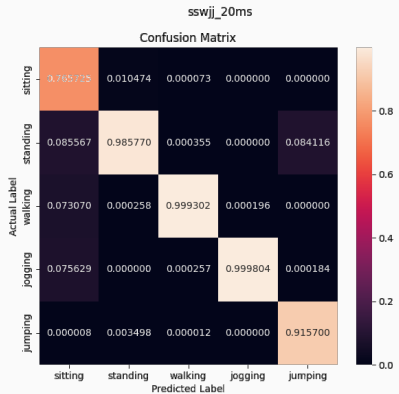
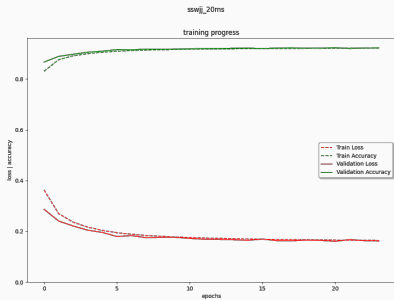


SSWJ 50Hz



SJ 50Hz





Conclusion

HAR based on IMU and RNN

1. develop IMU components ✓
 - low-cost: 400€ / athlete
2. build HAR datasets ✓
 - custom-made: sitting, standing, walking, jogging, jumping
3. train RNN models ✓
 - state-of-the-art: 0.99 accuracy

HAR based on IMU and RNN

1. develop IMU components

- validate home-designed devices and their loading docks
- develop CM5-based gateways, and analyzer unit board

2. build HAR datasets

- dealing with more activities: running, sprinting
- dealing with activities and sub-activities

3. predict human activity

- evaluate activity repetition counting
- evaluate activity beginning and end accuracy

4. estimate activity features

- compute run speed, run distance, and jump height

Sensor Fusion

LPS local positioning system

CV computer vision

Radar

- jumping demonstrator
force sensors, IMU, LPS, Radar, CV, musculoskeletal simulation
- robot for table officials in basketball

thank you