Anomaly detection in quasi-periodic energy consumption data series: a comparison of algorithms - Annex

Basic Statistics Results

Performance:

Training Period	Fridge 1				Fridge 2				Fridge 3			
	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	0.109	0.790	0.192	0.415	0.146	0.864	0.250	0.592	0.029	0.974	0.057	0.636
3 weeks	0.103	0.744	0.182	0.230	0.147	0.863	0.251	1.039	0.029	0.974	0.057	0.440
2 weeks	0.111	0.804	0.195	0.333	0.288	0.857	0.431	unlimited	0.029	0.974	0.057	0.835

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge1	0.108	0.004	0.779	0.031	0.190	0.007
Fridge2	0.194	0.082	0.861	0.004	0.311	0.104
Fridge3	0.029	0.000	0.974	0.000	0.057	0.000
Overall	0.110	0.082	0.871	0.086	0.186	0.122

AR Results

Performance:

Training Period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	0.5p	0.781	0.758	0.769	18.028	0.671	0.817	0.737	13.082	0.970	0.805	0.880	26.066
3 weeks	0.5p	0.744	0.769	0.756	18.872	0.676	0.816	0.739	13.806	0.970	0.805	0.880	26.690
2 weeks	0.5p	0.805	0.719	0.760	20.886	0.669	0.821	0.737	13.233	0.972	0.807	0.882	27.069

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.7766	0.0305	0.7488	0.0261	0.7618	0.0067
Fridge 2	0.6717	0.0035	0.8179	0.0027	0.7376	0.0012
Fridge 3	0.9710	0.0011	0.8054	0.0009	0.8805	0.0010
Overall	0.8064	0.1324	0.7907	0.0345	0.7933	0.0663

ARIMA Results

Performance:

Training Period	Window size	Fridge 1				Fridge 2				Fridge 2			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	0.5p	0.516	0.194	0.282	11.064	0.187	0.975	0.314	0.025	0.364	0.102	0.160	17.285
3 weeks	0.5p	0.507	0.204	0.291	11.263	0.187	0.975	0.314	0.025	0.329	0.079	0.127	19.449
2 weeks	0.5p	0.148	0.572	0.235	2.412	0.187	0.975	0.314	0.025	0.199	0.065	0.098	19.624

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.390	0.210	0.324	0.215	0.270	0.030
Fridge 2	0.187	0.000	0.975	0.000	0.314	0.000
Fridge 3	0.297	0.087	0.082	0.019	0.128	0.031
Overall	0.292	0.144	0.460	0.414	0.237	0.087

LOF Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.474	0.813	0.599	-0.113	0.532	0.787	0.635	-0.310	0.597	0.970	0.739	0.463
1 month	2p	0.432	0.900	0.584	0.129	0.686	0.684	0.685	-0.272	0.823	0.953	0.883	0.869
1 month	1p	0.352	0.876	0.503	-0.258	0.492	0.881	0.632	-0.387	0.926	0.969	0.947	1.749
1 month	0.5p	0.440	0.594	0.505	1.171	0.240	0.836	0.373	-0.331	0.076	0.934	0.141	0.835
3 weeks	3p	0.325	0.926	0.481	-0.149	0.510	0.735	0.602	-0.298	0.637	0.967	0.768	0.541
3 weeks	2p	0.435	0.963	0.599	-0.111	0.618	0.734	0.671	-0.322	0.864	0.956	0.908	0.777
3 weeks	1p	0.380	0.936	0.540	-0.135	0.445	0.849	0.584	-0.380	0.907	0.970	0.937	1.578
3 weeks	0.5p	0.333	0.652	0.441	1.520	0.268	0.914	0.414	-0.166	0.182	0.925	0.304	0.509
2 weeks	3p	0.461	0.932	0.617	0.630	0.537	0.626	0.578	-0.311	0.619	0.964	0.754	0.527
2 weeks	2p	0.720	0.869	0.788	0.981	0.563	0.775	0.652	-0.322	0.786	0.933	0.854	0.926
2 weeks	1p	0.365	0.917	0.523	-0.215	0.499	0.861	0.632	-0.381	0.896	0.970	0.931	2.085
2 weeks	0.5p	0.281	0.724	0.404	1.515	0.272	0.924	0.420	-0.166	0.188	0.933	0.313	0.703

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.417	0.113	0.842	0.121	0.549	0.100
Fridge 2	0.472	0.142	0.801	0.093	0.573	0.108
Fridge 3	0.625	0.310	0.954	0.018	0.707	0.286
Overall	0.504	0.220	0.865	0.108	0.609	0.194

OC SVM

Performance:

Training Period	Window Size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.721	0.365	0.485	0.725	0.505	0.928	0.654	0.825	0.760	0.962	0.849	0.925
1 month	2p	0.495	0.909	0.641	0.925	0.681	0.941	0.790	0.825	0.860	0.962	0.908	0.900
1 month	1p	0.408	0.963	0.573	0.675	0.496	0.999	0.663	0.375	0.949	0.925	0.937	0.950
1 month	0.5p	0.682	0.666	0.674	0.575	0.717	0.899	0.798	0.650	0.932	0.968	0.950	0.575
3 weeks	3p	0.770	0.375	0.504	0.900	0.525	0.859	0.652	0.875	0.858	0.887	0.872	0.975
3 weeks	2p	0.702	0.774	0.737	0.600	0.672	0.927	0.779	0.825	0.793	0.964	0.870	0.925
3 weeks	1p	0.491	0.863	0.626	0.875	0.683	0.839	0.753	0.675	0.960	0.892	0.925	0.925
3 weeks	0.5p	0.784	0.701	0.740	0.700	0.417	0.752	0.536	0.450	0.932	0.968	0.950	0.575
2 weeks	3p	0.279	0.950	0.431	0.975	0.508	0.896	0.649	0.875	0.781	0.961	0.862	0.900
2 weeks	2p	0.309	0.933	0.464	0.950	0.687	0.934	0.791	0.825	0.940	0.936	0.938	0.900
2 weeks	1p	0.440	0.880	0.587	0.750	0.783	0.835	0.808	0.475	0.884	0.965	0.923	0.850
2 weeks	0.5p	0.692	0.795	0.740	0.600	0.462	0.688	0.553	0.300	0.875	0.970	0.920	0.550

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.564	0.181	0.765	0.207	0.600	0.111
Fridge 2	0.595	0.120	0.875	0.087	0.702	0.097
Fridge 3	0.877	0.069	0.947	0.030	0.909	0.036
Overall	0.679	0.192	0.862	0.148	0.737	0.156

ISOF Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.773	0.266	0.396	0.750	0.605	0.729	0.662	0.525	0.946	0.923	0.935	0.825
1 month	2p	0.769	0.837	0.801	0.600	0.719	0.908	0.802	0.525	0.947	0.965	0.956	0.775
1 month	1p	0.711	0.996	0.830	0.425	0.584	0.998	0.737	0.400	0.850	0.970	0.906	0.500
1 month	0.5p	0.750	0.933	0.832	0.475	0.651	0.924	0.764	0.550	0.923	0.970	0.946	0.450
3 weeks	3p	0.876	0.148	0.253	0.800	0.621	0.723	0.668	0.550	0.846	0.960	0.899	0.825
3 weeks	2p	0.874	0.375	0.525	0.700	0.723	0.905	0.804	0.525	0.941	0.967	0.954	0.775
3 weeks	1p	0.630	1.000	0.773	0.400	0.536	0.999	0.698	0.425	0.906	0.970	0.937	0.550
3 weeks	0.5p	0.732	0.951	0.827	0.450	0.616	0.965	0.752	0.525	0.909	0.970	0.939	0.450
2 weeks	3p	0.752	0.228	0.350	0.725	0.595	0.759	0.667	0.525	0.839	0.945	0.889	0.850
2 weeks	2p	0.876	0.542	0.670	0.675	0.682	0.925	0.785	0.500	0.912	0.969	0.940	0.775
2 weeks	1p	0.778	0.979	0.867	0.525	0.660	0.996	0.794	0.450	0.888	0.970	0.927	0.550
2 weeks	0.5p	0.651	0.950	0.772	0.400	0.606	0.974	0.747	0.525	0.943	0.968	0.955	0.450

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.764	0.081	0.684	0.343	0.658	0.218
Fridge 2	0.633	0.056	0.901	0.104	0.740	0.054
Fridge 3	0.904	0.040	0.962	0.014	0.932	0.022
Overall	0.767	0.127	0.849	0.235	0.777	0.172

GRU Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.962	0.688	0.802	0.150
1 month	2p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.958	0.629	0.759	0.150
1 month	1p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.982	0.717	0.829	0.150
1 month	0.5p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.962	0.695	0.807	0.150
3 weeks	3p	1.000	0.003	0.000	0.170	0.000	0.000	0.000	0.180	0.980	0.650	0.782	0.150
3 weeks	2p	1.000	0.005	0.000	0.170	0.000	0.000	0.000	0.180	0.905	0.794	0.846	0.150
3 weeks	1p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.989	0.761	0.860	0.150
3 weeks	0.5p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.960	0.663	0.784	0.150
2 weeks	3p	1.000	0.003	0.000	0.170	0.000	0.000	0.000	0.180	0.996	0.668	0.799	0.150
2 weeks	2p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.983	0.771	0.864	0.150
2 weeks	1p	1.000	0.001	0.000	0.170	0.000	0.000	0.000	0.180	0.961	0.698	0.808	0.150
2 weeks	0.5p	0.000	0.000	0.000	0.170	0.000	0.000	0.000	0.180	0.981	0.683	0.805	0.150

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.333	0.492	0.001	0.002	0.000	0.000
Fridge 2	0.000	0.000	0.000	0.000	0.000	0.000
Fridge 3	0.968	0.024	0.701	0.051	0.812	0.032
Overall	0.434	0.492	0.234	0.336	0.271	0.389

LSTM Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.994	0.063	0.119	0.170	1.000	0.001	0.001	0.180	0.942	0.660	0.776	0.150
1 month	2p	0.995	0.079	0.147	0.170	0.000	0.000	0.000	0.180	0.999	0.785	0.879	0.150
1 month	1p	0.997	0.157	0.271	0.170	1.000	0.002	0.004	0.180	0.963	0.698	0.809	0.150
1 month	0.5p	0.997	0.139	0.244	0.170	0.000	0.000	0.000	0.180	0.982	0.741	0.845	0.150
3 weeks	3p	0.997	0.124	0.221	0.170	0.500	0.001	0.001	0.180	0.964	0.773	0.858	0.150
3 weeks	2p	0.994	0.069	0.129	0.170	0.500	0.001	0.001	0.180	0.983	0.775	0.867	0.150
3 weeks	1p	0.997	0.157	0.271	0.170	0.000	0.000	0.000	0.180	0.974	0.674	0.797	0.150
3 weeks	0.5p	0.990	0.039	0.000	0.170	0.000	0.000	0.000	0.180	0.961	0.693	0.806	0.150
2 weeks	3p	0.991	0.046	0.087	0.170	0.000	0.000	0.000	0.180	0.984	0.774	0.866	0.150
2 weeks	2p	0.996	0.092	0.168	0.170	0.500	0.001	0.001	0.180	0.989	0.779	0.871	0.150
2 weeks	1p	0.994	0.065	0.122	0.170	0.500	0.001	0.001	0.180	0.966	0.786	0.867	0.150
2 weeks	0.5p	0.997	0.157	0.271	0.170	0.000	0.000	0.000	0.180	0.977	0.772	0.862	0.150

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.995	0.003	0.099	0.045	0.171	0.086
Fridge 2	0.333	0.389	0.000	0.001	0.001	0.001
Fridge 3	0.974	0.015	0.742	0.047	0.842	0.035
Overall	0.767	0.380	0.281	0.336	0.338	0.372

GRU-MS Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.338	0.699	0.455	212.190	0.512	0.710	0.595	5.222	0.579	0.657	0.616	11.437
1 month	2p	0.394	0.766	0.521	178.956	0.480	0.748	0.585	3.368	0.618	0.652	0.635	3.845
1 month	1p	0.291	0.830	0.430	543.061	0.484	0.757	0.591	2.541	0.611	0.696	0.651	9.177
1 month	0.5p	0.215	0.424	0.285	244.311	0.386	0.650	0.485	7.856	0.343	0.630	0.445	3.604
3 weeks	3p	0.394	0.878	0.544	363.682	0.509	0.681	0.583	9.837	0.585	0.649	0.615	6.228
3 weeks	2p	0.442	0.755	0.558	215.244	0.519	0.713	0.601	2.866	0.586	0.658	0.620	7.723
3 weeks	1p	0.311	0.560	0.400	88.874	0.468	0.720	0.568	12.444	0.604	0.640	0.621	7.217
3 weeks	0.5p	0.244	0.794	0.373	767.927	0.369	0.695	0.482	8.974	0.338	0.632	0.440	3.879
2 weeks	3p	0.412	0.792	0.542	138.735	0.532	0.676	0.595	2.334	0.568	0.648	0.605	3.556
2 weeks	2p	0.349	0.880	0.500	212.572	0.499	0.709	0.586	1.686	0.478	0.766	0.589	11.593
2 weeks	1p	0.272	0.882	0.416	569.929	0.430	0.741	0.544	5.841	0.633	0.585	0.608	1.606
2 weeks	0.5p	0.267	0.876	0.409	854.188	0.384	0.648	0.482	6.691	0.334	0.632	0.437	4.233

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.327	0.073	0.761	0.141	0.453	0.083
Fridge 2	0.464	0.058	0.704	0.036	0.558	0.048
Fridge 3	0.523	0.118	0.654	0.044	0.574	0.082
Overall	0.438	0.118	0.706	0.096	0.528	0.089

LSTM-MS Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.429	0.835	0.567	161.952	0.512	0.710	0.595	6.342	0.526	0.653	0.583	7.217
1 month	2p	0.353	0.639	0.455	161.816	0.480	0.748	0.585	3.826	0.634	0.651	0.642	4.037
1 month	1p	0.301	0.601	0.401	128.211	0.484	0.757	0.591	8.440	0.634	0.561	0.595	1.524
1 month	0.5p	0.248	0.493	0.330	201.519	0.386	0.650	0.485	6.495	0.373	0.729	0.494	3.763
3 weeks	3p	0.410	0.846	0.552	205.283	0.509	0.681	0.583	5.920	0.595	0.654	0.623	8.978
3 weeks	2p	0.382	0.750	0.507	183.394	0.519	0.713	0.601	5.285	0.636	0.653	0.645	5.667
3 weeks	1p	0.362	0.621	0.457	35.642	0.468	0.720	0.568	11.673	0.495	0.629	0.554	6.856
3 weeks	0.5p	0.263	0.558	0.358	317.820	0.369	0.695	0.482	9.181	0.339	0.630	0.440	4.116
2 weeks	3p	0.329	0.869	0.477	306.413	0.532	0.676	0.595	4.067	0.591	0.652	0.620	5.734
2 weeks	2p	0.400	0.824	0.539	341.794	0.499	0.709	0.586	5.176	0.629	0.651	0.640	3.936
2 weeks	1p	0.320	0.758	0.450	224.837	0.430	0.741	0.544	9.550	0.526	0.529	0.527	1.729
2 weeks	0.5p	0.244	0.490	0.326	301.206	0.384	0.648	0.482	6.942	0.334	0.628	0.436	4.011

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.337	0.063	0.690	0.140	0.452	0.083
Fridge 2	0.464	0.058	0.704	0.036	0.558	0.048
Fridge 3	0.526	0.117	0.635	0.050	0.567	0.076
Overall	0.442	0.114	0.676	0.091	0.525	0.087

GRU-AE Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.239	0.841	0.372	0.019	0.598	0.408	0.485	0.028	0.940	0.768	0.846	0.036
1 month	2p	0.446	0.644	0.527	0.021	0.955	0.238	0.381	0.047	1.000	0.764	0.866	0.036
1 month	1p	0.998	0.303	0.464	0.022	1.000	0.244	0.393	0.028	1.000	0.512	0.678	0.040
1 month	0.5p	0.998	0.270	0.425	0.037	1.000	0.002	0.004	0.026	1.000	0.254	0.405	0.059
3 weeks	3p	0.372	0.774	0.502	0.054	0.447	0.569	0.501	0.026	0.977	0.776	0.865	0.032
3 weeks	2p	0.528	0.703	0.603	0.025	0.811	0.376	0.514	0.029	1.000	0.551	0.711	0.042
3 weeks	1p	0.888	0.346	0.499	0.020	1.000	0.262	0.415	0.022	1.000	0.606	0.755	0.055
3 weeks	0.5p	0.998	0.270	0.425	0.037	1.000	0.004	0.009	0.027	1.000	0.251	0.401	0.072
2 weeks	3p	0.279	0.845	0.419	0.042	0.576	0.741	0.648	0.030	0.821	0.796	0.808	0.080
2 weeks	2p	0.481	0.743	0.584	0.026	0.745	0.347	0.474	0.025	0.997	0.772	0.870	0.043
2 weeks	1p	0.818	0.348	0.488	0.027	1.000	0.127	0.225	0.032	1.000	0.634	0.776	0.050
2 weeks	0.5p	0.998	0.271	0.427	0.036	1.000	0.031	0.061	0.021	1.000	0.433	0.604	0.072

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.670	0.307	0.530	0.246	0.478	0.070
Fridge 2	0.844	0.204	0.279	0.227	0.342	0.216
Fridge 3	0.978	0.053	0.593	0.199	0.715	0.168
Overall	0.831	0.245	0.467	0.258	0.512	0.222

LSTM-AE Results

Performance:

Training period	Window size	Fridge 1				Fridge 2				Fridge 3			
		Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold	Precision	Recall	F1	Threshold
1 month	3p	0.311	0.785	0.446	0.033	0.584	0.623	0.603	0.034	1.000	0.725	0.840	0.031
1 month	2p	0.663	0.477	0.555	0.040	0.944	0.284	0.436	0.036	1.000	0.520	0.684	0.041
1 month	1p	0.957	0.272	0.424	0.017	1.000	0.176	0.299	0.039	1.000	0.569	0.726	0.045
1 month	0.5p	0.998	0.260	0.413	0.041	1.000	0.052	0.100	0.025	1.000	0.317	0.482	0.051
3 weeks	3p	0.297	0.833	0.438	0.044	0.455	0.689	0.548	0.210	1.000	0.707	0.828	0.037
3 weeks	2p	0.553	0.675	0.608	0.032	0.933	0.345	0.503	0.046	0.998	0.794	0.884	0.030
3 weeks	1p	0.926	0.308	0.462	0.032	1.000	0.236	0.382	0.025	1.000	0.601	0.751	0.054
3 weeks	0.5p	0.998	0.230	0.373	0.062	1.000	0.062	0.117	0.033	1.000	0.293	0.454	0.072
2 weeks	3p	0.223	0.926	0.359	0.034	0.757	0.826	0.790	0.026	0.974	0.726	0.832	0.041
2 weeks	2p	0.484	0.705	0.574	0.029	0.745	0.524	0.615	0.028	1.000	0.731	0.845	0.050
2 weeks	1p	0.903	0.336	0.490	0.030	0.835	0.697	0.760	0.019	1.000	0.606	0.755	0.053
2 weeks	0.5p	0.998	0.273	0.428	0.036	0.698	0.787	0.740	0.021	1.000	0.611	0.759	0.063

Averages:

	Precision		Recall		F1	
	avg	std	avg	std	avg	std
Fridge 1	0.693	0.307	0.507	0.260	0.464	0.078
Fridge 2	0.829	0.183	0.442	0.282	0.491	0.233
Fridge 3	0.998	0.007	0.600	0.159	0.737	0.138
Overall	0.840	0.237	0.516	0.242	0.564	0.201