# Epileptic EEG classification using Embedded Dynamic Mode Decomposition: Supplementary Document

## 1 Open-Source Code

All code and test scripts for this work can be found at https://github.com/jenniferhellar/emdmd.

## 2 Per-patient classification results, scalp EEG dataset

Table 1: Linear SVM classification results for the CHB-MIT sEEG dataset, SOP = 10 min.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| 01 | 200 | 68.8 | 0.994 | 0.996 | 0.990 | 1.000 | 0.989 |
| 02 | 80 | 58.4 | 0.990 | 0.985 | 0.974 | 1.000 | 0.980 |
| 04 | 120 | 68.6 | 0.808 | 0.818 | 0.611 | 0.870 | 0.745 |
| 05 | 160 | 67.0 | 0.855 | 0.866 | 0.711 | 0.901 | 0.810 |
| 06 | 240 | 66.4 | 0.705 | 0.704 | 0.409 | 0.701 | 0.709 |
| 07 | 80 | 65.0 | 0.962 | 0.968 | 0.920 | 0.957 | 0.967 |
| 09 | 80 | 67.0 | 0.864 | 0.872 | 0.716 | 0.912 | 0.817 |
| 10 | 240 | 68.6 | 0.867 | 0.867 | 0.734 | 0.884 | 0.851 |
| 13 | 120 | 65.0 | 0.975 | 0.973 | 0.950 | 0.949 | 1.000 |
| 14 | 120 | 67.8 | 0.830 | 0.815 | 0.648 | 0.789 | 0.870 |
| 16 | 80 | 64.6 | 0.789 | 0.758 | 0.557 | 0.740 | 0.839 |
| 17 | 80 | 68.4 | 0.951 | 0.953 | 0.896 | 0.980 | 0.922 |
| 18 | 80 | 66.6 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 20 | 80 | 67.2 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 22 | 120 | 68.6 | 0.751 | 0.757 | 0.497 | 0.777 | 0.725 |
| 23 | 80 | 71.2 | 0.953 | 0.931 | 0.868 | 0.962 | 0.944 |
| Mean | 122.5 | 66.8 | 0.893 | 0.891 | 0.780 | 0.901 | 0.885 |

Table 2: Random forest classification results for the CHB-MIT sEEG dataset, SOP = 10 min.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| 01 | 200 | 68.8 | 0.985 | 0.985 | 0.970 | 0.981 | 0.989 |
| 02 | 80 | 58.4 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 04 | 120 | 68.6 | 0.830 | 0.820 | 0.651 | 0.796 | 0.864 |
| 05 | 160 | 67.0 | 0.864 | 0.865 | 0.725 | 0.865 | 0.862 |
| 06 | 240 | 66.4 | 0.736 | 0.748 | 0.473 | 0.790 | 0.681 |
| 07 | 80 | 65.0 | 0.961 | 0.951 | 0.897 | 0.962 | 0.960 |
| 09 | 80 | 67.0 | 0.853 | 0.851 | 0.713 | 0.857 | 0.850 |
| 10 | 240 | 68.6 | 0.888 | 0.895 | 0.775 | 0.959 | 0.817 |
| 13 | 120 | 65.0 | 0.911 | 0.910 | 0.815 | 0.905 | 0.917 |
| 14 | 120 | 67.8 | 0.829 | 0.796 | 0.654 | 0.739 | 0.919 |
| 16 | 80 | 64.6 | 0.795 | 0.765 | 0.549 | 0.800 | 0.789 |
| 17 | 80 | 68.4 | 0.951 | 0.957 | 0.898 | 0.960 | 0.942 |
| 18 | 80 | 66.6 | 0.991 | 0.982 | 0.972 | 1.000 | 0.982 |
| 20 | 80 | 67.2 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 22 | 120 | 68.6 | 0.711 | 0.749 | 0.416 | 0.826 | 0.596 |
| 23 | 80 | 71.2 | 0.917 | 0.899 | 0.814 | 0.942 | 0.892 |
| Mean | 122.5 | 66.8 | 0.889 | 0.886 | 0.770 | 0.899 | 0.879 |

Table 3: Linear SVM classification results for the CHB-MIT sEEG dataset, SOP = 30 min.

| **Case** | **Segments** | **Features** | **AUROC** | **F1** | **KAP** | **SEN** | **SPE** |
|---|---|---|---|---|---|---|---|
| 01 | 600 | 68.6 | 0.998 | 0.998 | 0.997 | 1.000 | 0.997 |
| 02 | 240 | 57.6 | 0.988 | 0.988 | 0.975 | 1.000 | 0.975 |
| 04 | 360 | 67.8 | 0.861 | 0.862 | 0.721 | 0.882 | 0.840 |
| 05 | 480 | 68.6 | 0.831 | 0.831 | 0.660 | 0.827 | 0.835 |
| 06 | 608 | 64.2 | 0.721 | 0.716 | 0.438 | 0.715 | 0.727 |
| 07 | 240 | 65.0 | 0.967 | 0.967 | 0.933 | 0.983 | 0.950 |
| 09 | 240 | 67.0 | 0.871 | 0.874 | 0.742 | 0.907 | 0.835 |
| 10 | 720 | 65.4 | 0.864 | 0.861 | 0.724 | 0.865 | 0.863 |
| 13 | 360 | 61.8 | 0.983 | 0.984 | 0.966 | 0.984 | 0.982 |
| 14 | 360 | 65.8 | 0.875 | 0.876 | 0.749 | 0.884 | 0.866 |
| 16 | 240 | 66.6 | 0.854 | 0.854 | 0.708 | 0.858 | 0.851 |
| 17 | 240 | 66.2 | 0.988 | 0.988 | 0.975 | 1.000 | 0.975 |
| 18 | 240 | 64.4 | 0.988 | 0.987 | 0.975 | 0.983 | 0.992 |
| 20 | 240 | 69.4 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 22 | 360 | 65.6 | 0.741 | 0.740 | 0.478 | 0.745 | 0.737 |
| 23 | 240 | 63.2 | 0.904 | 0.906 | 0.808 | 0.917 | 0.891 |
| Mean | 360.5 | 65.5 | 0.902 | 0.902 | 0.803 | 0.909 | 0.895 |

Table 4: Random forest classification results for the CHB-MIT sEEG dataset, SOP = 30 min.

| **Case** | **Segments** | **Features** | **AUROC** | **F1** | **KAP** | **SEN** | **SPE** |
|---|---|---|---|---|---|---|---|
| 01 | 600 | 68.6 | 0.990 | 0.990 | 0.980 | 0.987 | 0.993 |
| 02 | 240 | 57.6 | 0.988 | 0.988 | 0.975 | 1.000 | 0.975 |
| 04 | 360 | 67.8 | 0.880 | 0.880 | 0.760 | 0.872 | 0.889 |
| 05 | 480 | 68.6 | 0.854 | 0.853 | 0.703 | 0.868 | 0.839 |
| 06 | 608 | 64.2 | 0.722 | 0.727 | 0.436 | 0.764 | 0.681 |
| 07 | 240 | 65.0 | 0.958 | 0.959 | 0.917 | 0.958 | 0.958 |
| 09 | 240 | 67.0 | 0.888 | 0.896 | 0.775 | 0.959 | 0.817 |
| 10 | 720 | 65.4 | 0.888 | 0.890 | 0.768 | 0.963 | 0.812 |
| 13 | 360 | 61.8 | 0.958 | 0.959 | 0.916 | 0.977 | 0.939 |
| 14 | 360 | 65.8 | 0.912 | 0.907 | 0.822 | 0.884 | 0.941 |
| 16 | 240 | 66.6 | 0.879 | 0.872 | 0.758 | 0.833 | 0.925 |
| 17 | 240 | 66.2 | 0.971 | 0.972 | 0.942 | 0.992 | 0.950 |
| 18 | 240 | 64.4 | 0.987 | 0.988 | 0.975 | 1.000 | 0.975 |
| 20 | 240 | 69.4 | 0.987 | 0.988 | 0.975 | 0.984 | 0.991 |
| 22 | 360 | 65.6 | 0.828 | 0.833 | 0.651 | 0.870 | 0.785 |
| 23 | 240 | 63.2 | 0.916 | 0.919 | 0.833 | 0.942 | 0.891 |
| Mean | 360.5 | 65.5 | 0.913 | 0.914 | 0.824 | 0.928 | 0.897 |

# 3 Per-patient classification results, intracranial EEG dataset

Table 5: Linear SVM classification results for the Kaggle iEEG dataset, SOP = 10 min.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 120 | 42.2 | 0.907 | 0.910 | 0.813 | 0.934 | 0.881 |
| Patient_2 | 120 | 115.6 | 0.838 | 0.829 | 0.676 | 0.820 | 0.856 |
| Dog_1 | 160 | 55.4 | 0.741 | 0.735 | 0.483 | 0.719 | 0.762 |
| Dog_2 | 280 | 55.6 | 0.817 | 0.814 | 0.628 | 0.823 | 0.811 |
| Dog_3 | 480 | 49.6 | 0.781 | 0.775 | 0.558 | 0.769 | 0.792 |
| Dog_4 | 680 | 52.4 | 0.743 | 0.737 | 0.476 | 0.746 | 0.739 |
| Dog_5 | 200 | 47.2 | 0.809 | 0.809 | 0.612 | 0.831 | 0.786 |
| Mean | 291.4 | 59.7 | 0.805 | 0.801 | 0.607 | 0.806 | 0.804 |

Table 6: Random forest classification results for the Kaggle iEEG dataset, SOP = 10 min.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 120 | 42.2 | 0.927 | 0.921 | 0.849 | 0.886 | 0.968 |
| Patient_2 | 120 | 115.6 | 0.829 | 0.806 | 0.659 | 0.744 | 0.915 |
| Dog_1 | 160 | 55.4 | 0.769 | 0.783 | 0.536 | 0.838 | 0.699 |
| Dog_2 | 280 | 55.6 | 0.863 | 0.871 | 0.721 | 0.945 | 0.781 |
| Dog_3 | 480 | 49.6 | 0.792 | 0.793 | 0.582 | 0.804 | 0.780 |
| Dog_4 | 680 | 52.4 | 0.799 | 0.781 | 0.589 | 0.741 | 0.856 |
| Dog_5 | 200 | 47.2 | 0.870 | 0.871 | 0.732 | 0.913 | 0.826 |
| Mean | 291.4 | 59.7 | 0.836 | 0.832 | 0.667 | 0.839 | 0.832 |

Table 7: Linear SVM classification results for the Kaggle iEEG dataset, SOP = 30 min.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 360 | 37.8 | 0.938 | 0.939 | 0.877 | 0.949 | 0.928 |
| Patient_2 | 360 | 121.2 | 0.752 | 0.752 | 0.502 | 0.771 | 0.732 |
| Dog_1 | 480 | 51.2 | 0.657 | 0.653 | 0.313 | 0.652 | 0.663 |
| Dog_2 | 840 | 48.2 | 0.859 | 0.860 | 0.716 | 0.876 | 0.841 |
| Dog_3 | 1440 | 45.2 | 0.745 | 0.744 | 0.490 | 0.742 | 0.749 |
| Dog_4 | 1924 | 47.2 | 0.733 | 0.731 | 0.466 | 0.727 | 0.740 |
| Dog_5 | 600 | 39.0 | 0.832 | 0.831 | 0.666 | 0.823 | 0.841 |
| Mean | 857.7 | 55.7 | 0.788 | 0.787 | 0.576 | 0.791 | 0.785 |

Table 8: Random forest classification results for the Kaggle iEEG dataset, SOP = 30 min.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 360 | 37.8 | 0.954 | 0.953 | 0.905 | 0.957 | 0.950 |
| Patient_2 | 360 | 121.2 | 0.839 | 0.837 | 0.677 | 0.834 | 0.844 |
| Dog_1 | 480 | 51.2 | 0.734 | 0.728 | 0.465 | 0.719 | 0.748 |
| Dog_2 | 840 | 48.2 | 0.862 | 0.872 | 0.723 | 0.938 | 0.786 |
| Dog_3 | 1440 | 45.2 | 0.770 | 0.771 | 0.540 | 0.778 | 0.763 |
| Dog_4 | 1924 | 47.2 | 0.777 | 0.769 | 0.555 | 0.744 | 0.810 |
| Dog_5 | 600 | 39.0 | 0.889 | 0.890 | 0.776 | 0.904 | 0.873 |
| Mean | 857.7 | 55.7 | 0.832 | 0.831 | 0.663 | 0.839 | 0.825 |

# 4 Per-patient classification results, intracranial EEG dataset, first 3-4 seizures and first 4 interictal hours only

Table 9: Linear SVM classification results for the Kaggle iEEG dataset, SOP = 10 min, subset.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 120 | 43.6 | 0.856 | 0.854 | 0.699 | 0.860 | 0.852 |
| Patient_2 | 120 | 112.4 | 0.871 | 0.851 | 0.732 | 0.788 | 0.953 |
| Dog_1 | 160 | 49.2 | 0.882 | 0.880 | 0.762 | 0.864 | 0.899 |
| Dog_2 | 160 | 50.8 | 0.925 | 0.927 | 0.849 | 0.939 | 0.911 |
| Dog_3 | 160 | 56.2 | 0.839 | 0.839 | 0.675 | 0.850 | 0.828 |
| Dog_4 | 160 | 51.4 | 0.987 | 0.988 | 0.975 | 0.988 | 0.987 |
| Dog_5 | 160 | 44.8 | 0.883 | 0.883 | 0.762 | 0.903 | 0.863 |
| Mean | 148.6 | 58.3 | 0.892 | 0.889 | 0.779 | 0.884 | 0.899 |

Table 10: Random forest classification results for the Kaggle iEEG dataset, SOP = 10 min, subset.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 120 | 43.6 | 0.975 | 0.973 | 0.950 | 0.949 | 1.000 |
| Patient_2 | 120 | 112.4 | 0.897 | 0.885 | 0.796 | 0.828 | 0.966 |
| Dog_1 | 160 | 49.2 | 0.927 | 0.925 | 0.850 | 0.938 | 0.915 |
| Dog_2 | 160 | 50.8 | 0.968 | 0.967 | 0.937 | 0.949 | 0.987 |
| Dog_3 | 160 | 56.2 | 0.863 | 0.843 | 0.725 | 0.751 | 0.976 |
| Dog_4 | 160 | 51.4 | 0.957 | 0.956 | 0.912 | 0.951 | 0.963 |
| Dog_5 | 160 | 44.8 | 0.916 | 0.914 | 0.826 | 0.940 | 0.892 |
| Mean | 148.6 | 58.3 | 0.929 | 0.923 | 0.856 | 0.901 | 0.957 |

Table 11: Linear SVM classification results for the Kaggle iEEG dataset, SOP = 30 min, subset.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 360 | 40.8 | 0.925 | 0.924 | 0.849 | 0.921 | 0.928 |
| Patient_2 | 360 | 121.8 | 0.816 | 0.805 | 0.627 | 0.790 | 0.841 |
| Dog_1 | 480 | 50.0 | 0.809 | 0.806 | 0.615 | 0.808 | 0.811 |
| Dog_2 | 480 | 41.6 | 0.946 | 0.948 | 0.894 | 0.953 | 0.939 |
| Dog_3 | 480 | 52.0 | 0.869 | 0.870 | 0.738 | 0.884 | 0.853 |
| Dog_4 | 480 | 55.0 | 0.972 | 0.970 | 0.941 | 0.967 | 0.976 |
| Dog_5 | 480 | 41.4 | 0.889 | 0.886 | 0.774 | 0.877 | 0.901 |
| Mean | 445.7 | 57.5 | 0.889 | 0.887 | 0.777 | 0.886 | 0.893 |

Table 12: Random forest classification results for the Kaggle iEEG dataset, SOP = 30 min, subset.

| Case | Segments | Features | AUROC | F1 | KAP | SEN | SPE |
|---|---|---|---|---|---|---|---|
| Patient_1 | 360 | 40.8 | 0.965 | 0.963 | 0.928 | 0.952 | 0.979 |
| Patient_2 | 360 | 121.8 | 0.868 | 0.859 | 0.733 | 0.809 | 0.928 |
| Dog_1 | 480 | 50.0 | 0.841 | 0.830 | 0.675 | 0.805 | 0.876 |
| Dog_2 | 480 | 41.6 | 0.960 | 0.960 | 0.920 | 0.966 | 0.954 |
| Dog_3 | 480 | 52.0 | 0.867 | 0.853 | 0.732 | 0.787 | 0.948 |
| Dog_4 | 480 | 55.0 | 0.977 | 0.977 | 0.954 | 0.962 | 0.991 |
| Dog_5 | 480 | 41.4 | 0.929 | 0.927 | 0.854 | 0.939 | 0.920 |
| Mean | 445.7 | 57.5 | 0.915 | 0.910 | 0.828 | 0.889 | 0.942 |