ADNI Progress report

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Part I

Using HMMs to predict disease progression

Training set: randomly picked 1000 patients.
Testing set: Remaining 398 patients.

1 Sanity Check

As a sanity check, the HMM was trained with the number of states $k = 3$.

Following are the temporal parameters, as learned by the HMM and contrasted with the ground truth.

$$gt.pi = \begin{bmatrix} 0.3062 & 0.4667 & 0.2272 \end{bmatrix}$$

$$model.pi = \begin{bmatrix} 0.4630 \pm 0.0453 & 0.3479 \pm 0.0276 & 0.1891 \pm 0.0330 \end{bmatrix}$$

$$gt.A = \begin{bmatrix} 0.9416 & 0.0584 & 0 \\ 0.0264 & 0.8516 & 0.1220 \\ 0 & 0 & 1 \end{bmatrix}$$

$$model.A = \begin{bmatrix} 0.975 \pm 0.013 & 0.019 \pm 0.013 & 0.006 \pm 0.005 \\ 0.000 \pm 0.000 & 0.977 \pm 0.005 & 0.023 \pm 0.005 \\ 0.000 \pm 0.000 & 0.000 \pm 0.000 & 1.000 \pm 0.000 \end{bmatrix}$$

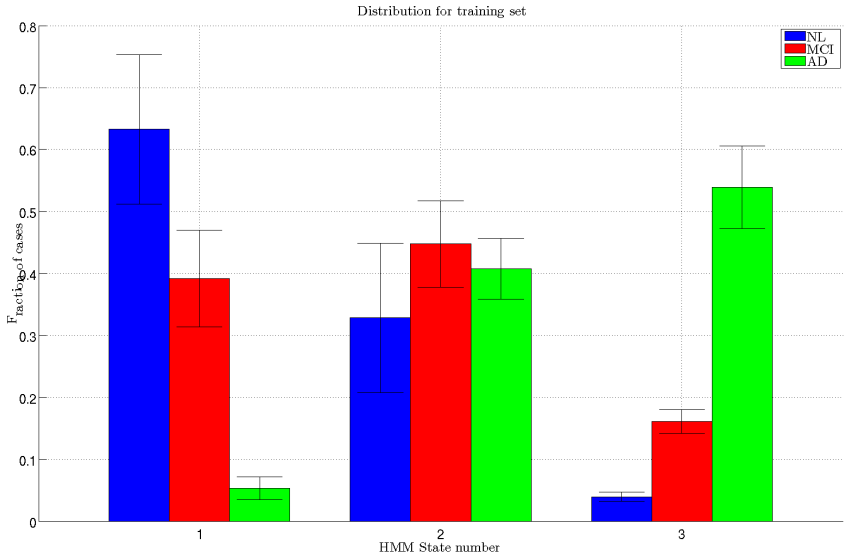

Figure 1: Distribution of states for training set

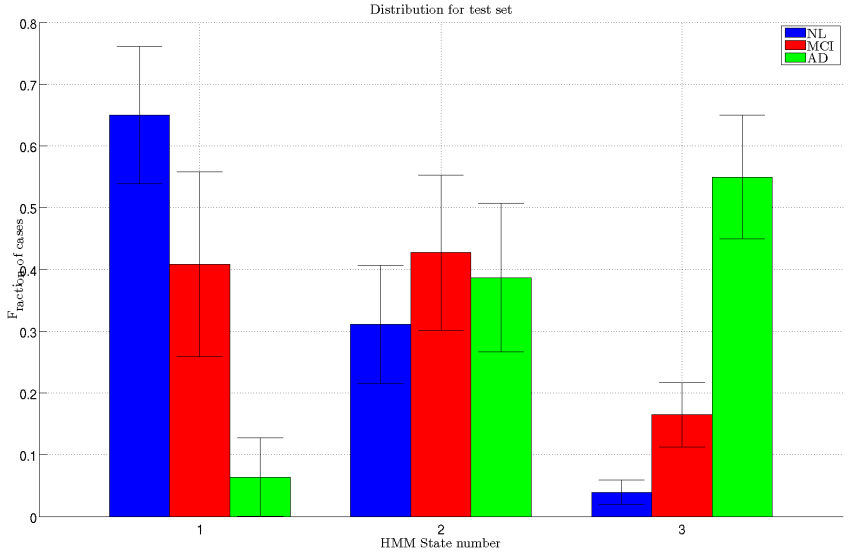

Figure 2: Distribution of states for testing set

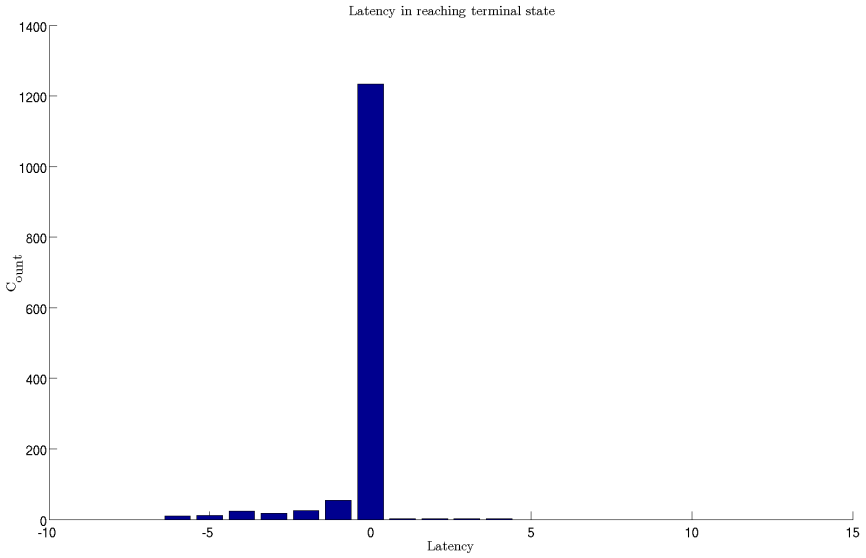

Figure 3: Distribution of latency

1.1 Analysing the transitions

1.2 K=3

Training set:

	$NL \to NL$	$MCI \to NL$	$NL \to MCI$
$1 \to 1$	0.591 ± 0.045	0.479 ± 0.127	0.412 ± 0.000
$1 \to 2$	0.002 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 2$	0.339 ± 0.000	0.375 ± 0.000	0.494 ± 0.000
$1 \to 3$	0.002 ± 0.002	0.000 ± 0.000	0.000 ± 0.000
$2 \to 3$	0.001 ± 0.063	0.000 ± 0.054	0.000 ± 0.000
$3 \to 3$	0.066 ± 0.000	0.146 ± 0.000	0.093 ± 0.000
$TotalCount$	344.000 ± 37.242	16.000 ± 1.000	21.333 ± 5.508

	$MCI \to MCI$	$MCI \to AD$	$AD \to AD$
$1 \to 1$	0.333 ± 0.036	0.139 ± 0.033	0.026 ± 0.000
$1 \to 2$	0.003 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 2$	0.466 ± 0.000	0.390 ± 0.000	0.384 ± 0.000
$1 \to 3$	0.001 ± 0.000	0.009 ± 0.002	0.004 ± 0.000
$2 \to 3$	0.002 ± 0.061	0.022 ± 0.041	0.010 ± 0.000
$3 \to 3$	0.196 ± 0.000	0.440 ± 0.000	0.576 ± 0.000
$TotalCount$	517.000 ± 4.359	74.000 ± 3.606	234.667 ± 10.263

Testing Set:

	$NL \to NL$	$MCI \to NL$	$NL \to MCI$
$1 \to 1$	0.608 ± 0.126	0.532 ± 0.122	0.488 ± 0.000
$1 \to 2$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 2$	0.328 ± 0.000	0.337 ± 0.000	0.440 ± 0.000
$1 \to 3$	0.004 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 3$	0.004 ± 0.065	0.000 ± 0.089	0.000 ± 0.000
$3 \to 3$	0.056 ± 0.000	0.131 ± 0.000	0.072 ± 0.000
$TotalCount$	172.000 ± 37.242	8.000 ± 1.000	10.667 ± 5.508

	$MCI \to MCI$	$MCI \to AD$	$AD \to AD$
$1 \to 1$	0.326 ± 0.119	0.134 ± 0.039	0.034 ± 0.000
$1 \to 2$	0.003 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 2$	0.491 ± 0.000	0.434 ± 0.000	0.381 ± 0.000
$1 \to 3$	0.003 ± 0.000	0.010 ± 0.002	0.003 ± 0.000
$2 \to 3$	0.004 ± 0.092	0.008 ± 0.095	0.012 ± 0.000
$3 \to 3$	0.173 ± 0.000	0.413 ± 0.000	0.570 ± 0.000
$TotalCount$	258.000 ± 4.359	37.000 ± 3.606	117.333 ± 10.263

2 K=5

Training Set:

	$NL \rightarrow NL$	$MCI \rightarrow NL$	$NL \rightarrow MCI$
$1 \rightarrow 1$	0.398 ± 0.066	0.394 ± 0.079	0.215 ± 0.000
$1 \rightarrow 2$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \rightarrow 2$	0.326 ± 0.000	0.291 ± 0.000	0.279 ± 0.000
$1 \rightarrow 3$	0.004 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \rightarrow 3$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$3 \rightarrow 3$	0.186 ± 0.000	0.170 ± 0.000	0.343 ± 0.000
$1 \rightarrow 4$	0.000 ± 0.081	0.000 ± 0.023	0.000 ± 0.000
$3 \rightarrow 4$	0.004 ± 0.000	0.000 ± 0.000	0.018 ± 0.000
$4 \rightarrow 4$	0.049 ± 0.000	0.064 ± 0.000	0.116 ± 0.000
$1 \rightarrow 5$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \rightarrow 5$	0.001 ± 0.002	0.000 ± 0.000	0.000 ± 0.000
$4 \rightarrow 5$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$5 \rightarrow 5$	0.032 ± 0.035	0.081 ± 0.099	0.030 ± 0.000
$TotalCount$	344.000 ± 10.000	16.000 ± 1.000	21.333 ± 2.517

	$MCI \rightarrow MCI$	$MCI \rightarrow AD$	$AD \rightarrow AD$
$1 \rightarrow 1$	0.200 ± 0.050	0.085 ± 0.039	0.015 ± 0.000
$1 \rightarrow 2$	0.000 ± 0.000	0.000 ± 0.000	0.001 ± 0.000
$2 \rightarrow 2$	0.243 ± 0.000	0.097 ± 0.000	0.051 ± 0.000
$1 \rightarrow 3$	0.003 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \rightarrow 3$	0.001 ± 0.000	0.000 ± 0.000	0.002 ± 0.000
$3 \rightarrow 3$	0.294 ± 0.000	0.241 ± 0.000	0.212 ± 0.000
$1 \rightarrow 4$	0.001 ± 0.062	0.000 ± 0.105	0.000 ± 0.000
$3 \rightarrow 4$	0.004 ± 0.000	0.018 ± 0.000	0.011 ± 0.000
$4 \rightarrow 4$	0.133 ± 0.000	0.249 ± 0.000	0.287 ± 0.000
$1 \rightarrow 5$	0.001 ± 0.000	0.005 ± 0.000	0.003 ± 0.000
$2 \rightarrow 5$	0.003 ± 0.000	0.014 ± 0.001	0.005 ± 0.000
$4 \rightarrow 5$	0.000 ± 0.000	0.005 ± 0.001	0.001 ± 0.000
$5 \rightarrow 5$	0.118 ± 0.050	0.287 ± 0.063	0.412 ± 0.000
$TotalCount$	517.333 ± 8.737	74.333 ± 5.132	235.000 ± 18.520

Testing Set:

	$NL \to NL$	$MCI \to NL$	$NL \to MCI$
$1 \to 1$	0.418 ± 0.111	0.304 ± 0.313	0.230 ± 0.000
$1 \to 2$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 2$	0.296 ± 0.000	0.290 ± 0.000	0.221 ± 0.000
$1 \to 3$	0.002 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 3$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$3 \to 3$	0.184 ± 0.000	0.333 ± 0.000	0.410 ± 0.000
$3 \to 4$	0.002 ± 0.118	0.000 ± 0.042	0.000 ± 0.000
$4 \to 4$	0.053 ± 0.000	0.000 ± 0.000	0.114 ± 0.000
$1 \to 5$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 5$	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$4 \to 5$	0.000 ± 0.004	0.000 ± 0.000	0.000 ± 0.000
$5 \to 5$	0.044 ± 0.000	0.074 ± 0.000	0.026 ± 0.000
$TotalCount$	172.000 ± 10.000	8.000 ± 1.000	10.667 ± 2.517

	$MCI \to MCI$	$MCI \to AD$	$AD \to AD$
$1 \to 1$	0.223 ± 0.144	0.061 ± 0.031	0.013 ± 0.000
$1 \to 2$	0.003 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 2$	0.219 ± 0.000	0.159 ± 0.000	0.033 ± 0.000
$1 \to 3$	0.001 ± 0.000	0.000 ± 0.000	0.000 ± 0.000
$2 \to 3$	0.001 ± 0.000	0.008 ± 0.000	0.002 ± 0.000
$3 \to 3$	0.285 ± 0.000	0.226 ± 0.002	0.198 ± 0.000
$3 \to 4$	0.007 ± 0.035	0.011 ± 0.118	0.006 ± 0.000
$4 \to 4$	0.128 ± 0.000	0.193 ± 0.000	0.303 ± 0.000
$1 \to 5$	0.000 ± 0.000	0.009 ± 0.000	0.000 ± 0.000
$2 \to 5$	0.006 ± 0.000	0.011 ± 0.000	0.011 ± 0.000
$4 \to 5$	0.001 ± 0.000	0.000 ± 0.002	0.000 ± 0.000
$5 \to 5$	0.126 ± 0.000	0.322 ± 0.002	0.435 ± 0.000
$TotalCount$	257.667 ± 8.737	36.667 ± 5.132	117.000 ± 18.520

3 HMM with larger state space

$$model.pi = \begin{bmatrix} 0.2481 \pm 0.0425 & 0.2863 \pm 0.0224 & 0.2109 \pm 0.0186 & 0.1039 \pm 0.0060 & 0.1508 \pm 0.0 \end{bmatrix}$$

$$model.A = \begin{bmatrix} 0.981 \pm 0.006 & 0.006 \pm 0.010 & 0.009 \pm 0.011 & 0.002 \pm 0.003 & 0.002 \pm 0.003 \\ 0.001 \pm 0.001 & 0.962 \pm 0.004 & 0.016 \pm 0.002 & 0.003 \pm 0.005 & 0.018 \pm 0.009 \\ 0.000 \pm 0.000 & 0.000 \pm 0.000 & 0.951 \pm 0.020 & 0.049 \pm 0.020 & 0.000 \pm 0.000 \\ 0.000 \pm 0.000 & 0.000 \pm 0.000 & 0.000 \pm 0.000 & 0.992 \pm 0.011 & 0.008 \pm 0.011 \\ 0.000 \pm 0.000 & 0.000 \pm 0.000 & 0.000 \pm 0.000 & 0.000 \pm 0.000 & 1.000 \pm 0.000 \end{bmatrix}$$

4 Trellis plots

4.1 K=3

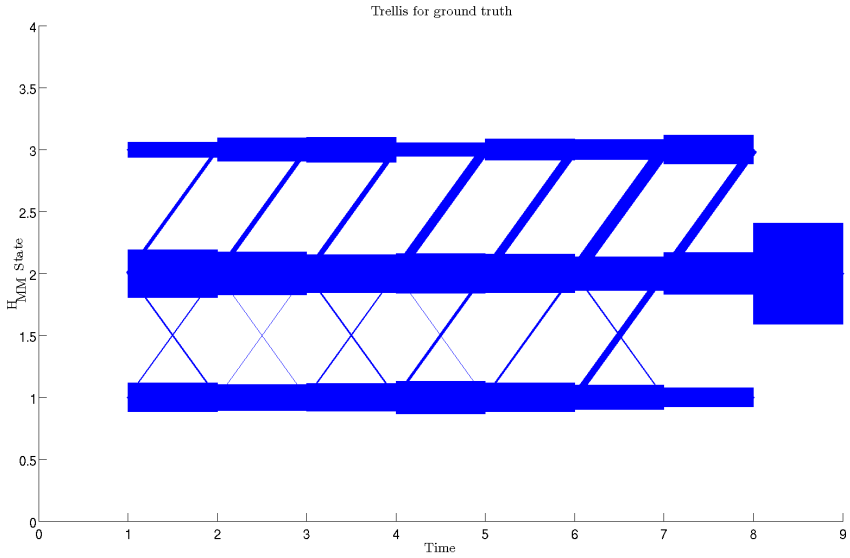

Figure 4: Trellis for ground truth

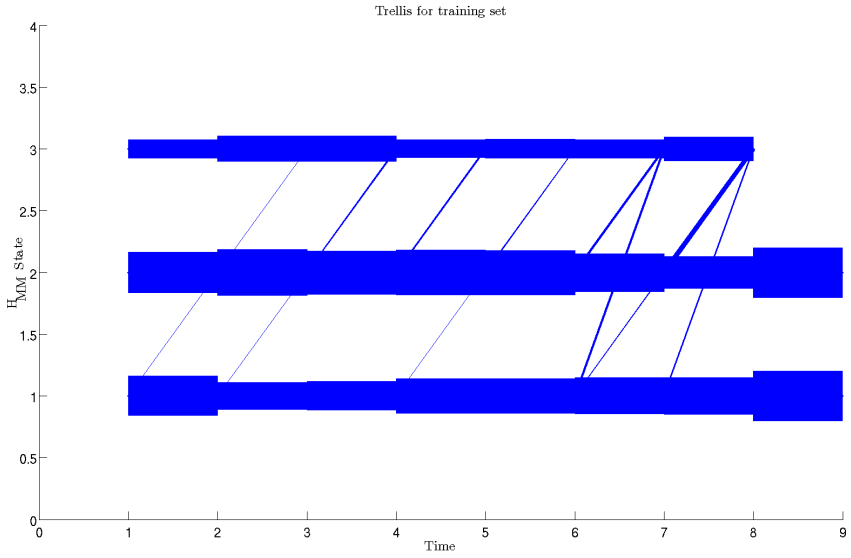

Figure 5: Trellis for training set

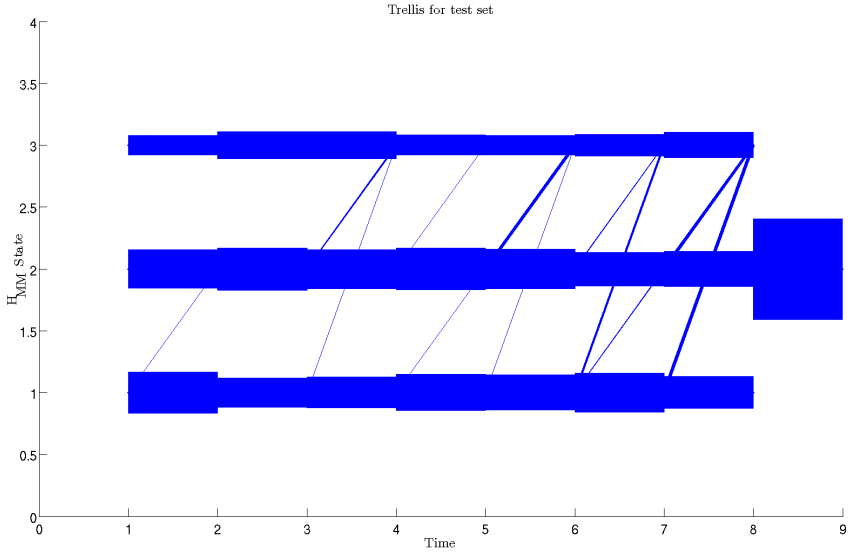

Figure 6: Trellis for test set

4.2 K=5

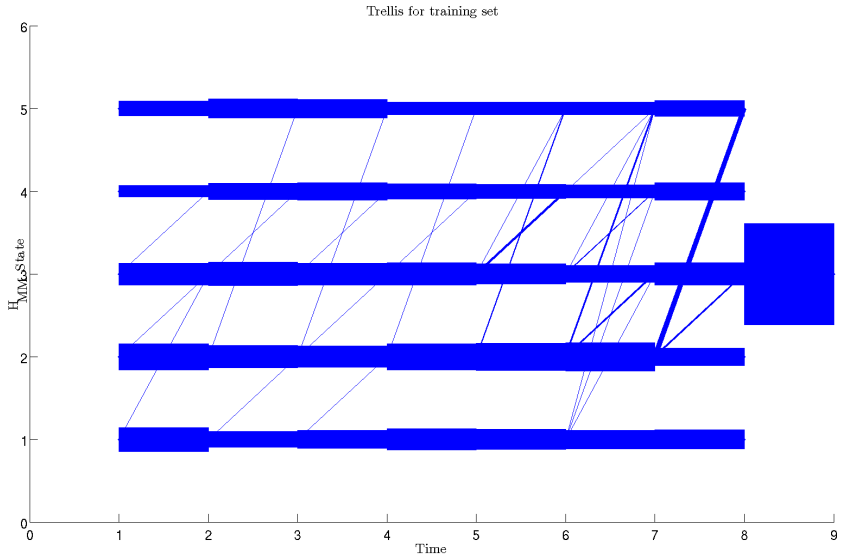

Figure 7: Trellis for training set

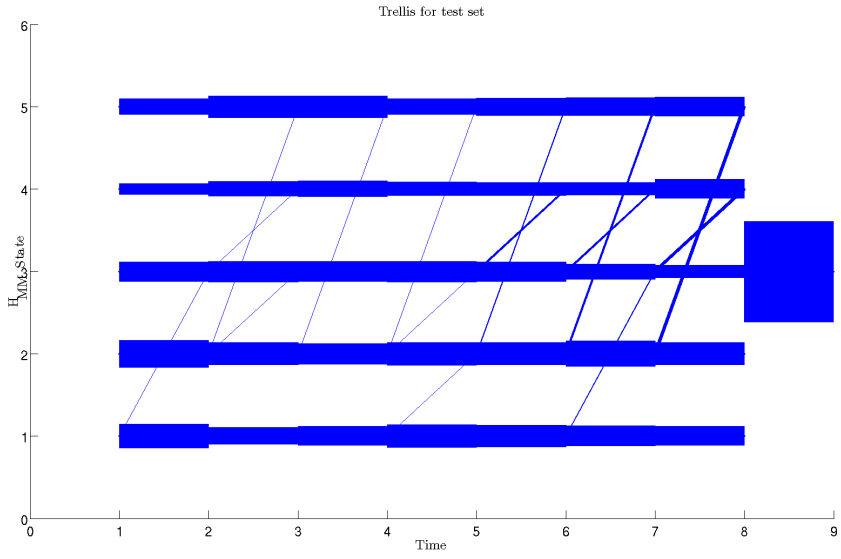

Figure 8: Trellis for test set