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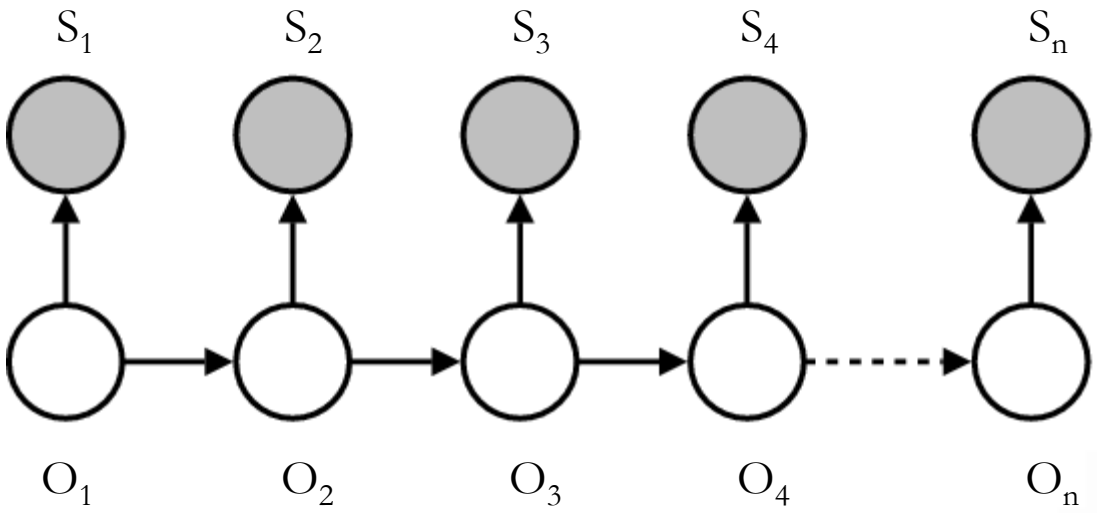
Summer 2012
Internship Report

MATLAB Codes

Original, Optimised, Efficient

- Hidden Markov Models
  - Forward Algorithm
  - Backward Algorithm
  - Baum-Welch Algorithm
  - Viterbi Algorithm
- Finger Tip Gesture Recognition

Hidden Markov Models



- **Pi** : Nx1 matrix : Vector of initial probabilities of states,
- **a** : NxN matrix : Probability of transition from state S_i to state S_j,
- **b** : NxM matrix : Probability of observing V_k for state S_i,
- **Ob** : Mx1 matrix : Vector of all possible observations,
- **O** : EGxT matrix : Matrix of EG no. of 1xT dimensional observation sets,
- **Alpha** : NxT matrix; Alpha(i,t) = Probability of observing partial observation sequence from start to time t, i.e. $O_1,O_2,...,O_t$, and being in state S_i, at time t,
- **Betaa** : NxM matrix; Betaa(i, find(Ob==O(eg,t),1)) = Probability of partial observation sequence from t+1 to end, i.e. $O_{t+1},\ldots,O_T$, given the state at time t was S_i.

Forward Algorithm

`[Alpha, c, P] = ForwardAlgo(Pi, a, b, Ob, O)`

- `Alpha(i,t)` is the probability of observing partial observation sequence from start to time t, i.e., $O_1, O_2, \ldots, O_t$, and being in state S_i, at time t
- `c` is a Tx1 matrix, c(t) = Probability of the partial observation sequence till time t, and
- `P` is an Nx1 matrix, P(n) = Probability of being in state S_n at the end time T.

"A Tutorial on Hidden Markov models" by Lawrence R. Rabiner

Backward Algorithm

```
Betaa = BackwardAlgo(Pi, a, b, Ob, O)
```

- `Betaa(i, find(Ob==O(eg,t),1))` is the probability of observing the partial observation sequence from time t+1 to end, i.e. $O_{t+1},\ldots,O_T$, given the state at time t was S_i

Baum-Welch Algorithm

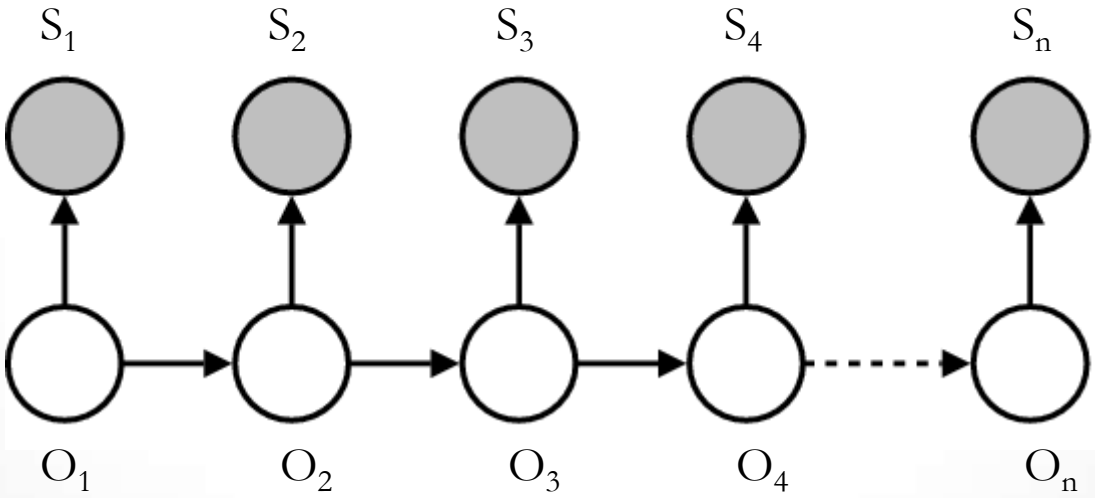
```
[PiNew, aNew, bNew, AlphaNew, BetaNew, logProb, lP]
 = BaumWelsh(Pi, a, b, Ob, O, Alpha, Betaa, iters,
             maxIters, oldLogProb, lP);
```

- Calculates new values of `Pi`, `a` and `b`.
- Recursion
- Employs Forward and Backward Algorithms

Viterbi Algorithm

```
Q = ViterbiAlgo(Pi, a, b, Ob, O)
```

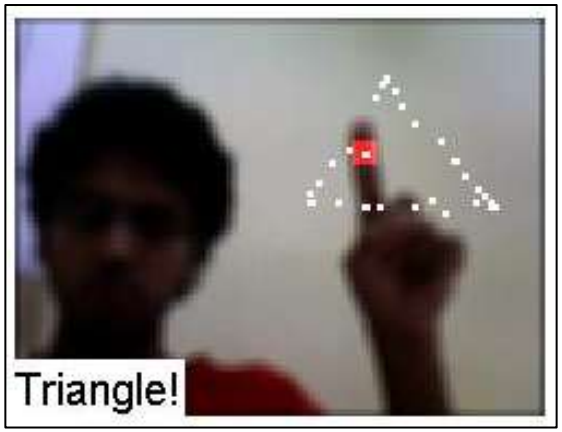
- Determines most probable State Sequence `Q`

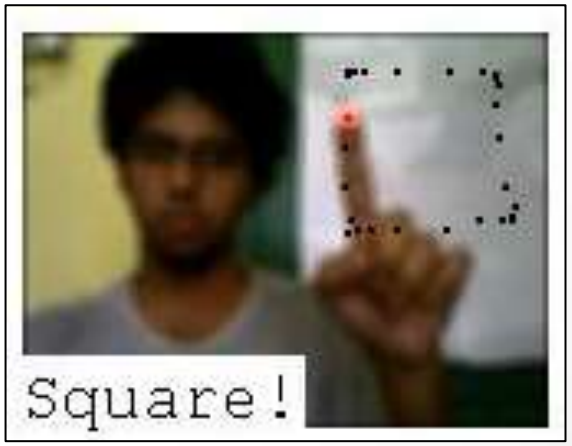


Finger-Tip Gesture Recognition

- Finger-Tip Recognition
  - Skin-pixel Segmentation
  - First pixel from top
- Finger-Tip Tracking
  - Store all finger-tip coordinates
- Gesture Recognition using HMM's
  - Use Viterbi Algorithm to determine most probable state sequence

Finger-Tip Gesture Recognition





Finger-Tip Gesture Recognition

- HMM 1: To determine the state among:

Right, Down, Left, Up, DR, DL, UL, UR

- Pi = [.4;
  .03;
  .03;
  .04;
  .4;
  .03;
  .03;
  .04];
- a = [.60 .25 .01 .01 .10 .01 .01 .01;
  .01 .60 .25 .01 .10 .01 .01 .01;
  .01 .01 .65 .15 .01 .01 .01 .15;
  .01 .01 .01 .93 .01 .01 .01 .01;
  .01 .01 .15 .01 .65 .15 .01 .01;
  .01 .05 .05 .01 .01 0.6 .25 .01;
  .01 .01 .055 .055 .01 .01 .60 .25;
  .01 .01 .01 .01 .01 .01 .01 .93];
- b(:,:,1) = [.10 .00 .90;
  .34 .33 .33;
  .10 .90 .00;
  .34 .33 .33;
  .10 .00 .90;
  .10 .90 .00;
  .10 .90 .00;
  .10 .00 .90];
  % for x coordinates
- b(:,:,2) = [.34 .33 .33;
  .10 .90 .00;
  .34 .33 .33;
  .10 .00 .90;
  .10 .90 .00;
  .10 .90 .00;
  .10 .00 .90;
  .10 .00 .90];
  % for y coordinates

- HMM 2: To determine the state among:

Triangle, Square, Diamond

- PI = [.34;
  .33;
  .33];
- A = [.98 .01 .01;
  .01 .98 .01;
  .01 .01 .98];
- B = [.09 .04 .25 .04 .25 .04 .04 .25;
  .22 .22 .22 .22 .03 .03 .03 .03;
  .03 .03 .03 .03 .22 .22 .22 .22];

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Thank You.