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HOME WORK 2

1. *Given the Bayesian network below, answer the following queries by hand. Show intermediate steps*
    a. $P(m)$

$$P(m) = \sum_B \sum_E \sum_A \sum_J P(B,E,A,J,m)$$

$$P(M) = \sum_B \sum_E \sum_A \sum_J P(B,E,A,J,M)$$

$$P(M) = \alpha \sum_B \sum_E \sum_A \sum_J P(B)P(E)P(A|B,E)P(J|A)P(M|A)$$

$$P(M) = \alpha \sum_B P(B) \sum_E P(E) \sum_A P(A|B,E) \sum_J P(J|A)P(M|A)$$

$$P(M) = \alpha \sum_B f_1(B) \sum_E f_2(E) \sum_A f_3(A,B,E) \sum_J f_4(J,A) f_5(M,A)$$

$f_5(M,A) =$

M	A	$f_5(M,A)$
T	T	0.7
T	F	0.01
F	T	0.3
F	F	0.99

$f_5(J,A) =$

J	A	$f_5(J,A)$
T	T	0.90
T	F	0.05
F	T	0.1
F	F	0.95

$$P(M) = \alpha \sum_B f_1(B) \sum_E f_2(E) \sum_A f_3(A,B,E) \sum_J f_4(J,A) f_5(M,A)$$

$$P(M) = \alpha \sum_B f_1(B) \sum_E f_2(E) \sum_A f_3(A,B,E) \sum_J f_6(J,M,A)$$

$$f_6(J,M,A) =$$

J	A	$f_4(J,A)$	M	A	$f_5(M,A)$	J	M	A	$f_6(J,M,A)$
T	T	0.90	T	T	0.7	T	T	T	*0.6300*
T	F	0.05	T	F	0.01	T	T	F	*0.0005*
F	T	0.1	F	T	0.3	T	F	T	0.2700

F	F	0.95	F	F	0.99	T	F	F	0.0495
						F	T	T	0.0700
						F	T	F	0.0095
						F	F	T	0.0300
						F	F	F	0.9405

$$P(M) = \alpha \sum_{B} f_1(B) \sum_{E} f_2(E) \sum_{A} f_3(A,B,E) f_7(M,A)$$

$f_7(M,A) =$

M	A	$f_7(M,A)$
T	T	0.7000
T	F	0.0100
F	T	0.3000
F	F	0.9900

$f_3(A,B,E) =$

A	B	E	$f_6(A,B,E)$
T	T	T	0.9500
T	T	F	0.9400
T	F	T	0.2900
T	F	F	0.0010
F	T	T	0.0500
F	T	F	0.0600
F	F	T	0.7100
F	F	F	0.9990

$$P(M) = \alpha \sum_{B} f_1(B) \sum_{E} f_2(E) \sum_{A} f_8(A,B,E,M)$$

$f_8(A,B,E,M) =$

A	B	E	M	$f_6(A,B,E)$
T	T	T	T	0.6650
T	T	F	T	0.6580
T	F	T	T	0.2030
T	F	F	T	0.0007
F	T	T	T	0.0005
F	T	F	T	0.0006
F	F	T	T	0.0071
F	F	F	T	0.0100
T	T	T	F	0.2850
T	T	F	F	0.2820

T	F	T	F	0.0870
T	F	F	F	0.0003
F	T	T	F	0.0495
F	T	F	F	0.0594
F	F	T	F	0.7029
F	F	F	F	0.9890

$$P(M) = \alpha \sum_B f_1(B) \sum_E f_2(E) f_9(B, E, M)$$

$f_9(B, E, M)$

M	B	E	$f_9(M, B, E)$
T	T	T	0.6655
T	T	F	0.6586
T	F	T	0.2101
T	F	F	0.0107
F	T	T	0.3345
F	T	F	0.3414
F	F	T	0.7899
F	F	F	0.9893

$f_2(E)$

E	$f_2(E)$
T	0.0020
F	0.9980

$$P(M) = \alpha \sum_B f_1(B) f_{10}(B, M)$$

$f_{10}(B, M)$

M	B	$f_{10}(M, B)$
T	T	0.6586
T	F	0.0111
F	T	0.3414
F	F	0.9889

$f_{10}(B, M) * f_1(B)$

M	B	$f_{10}(M, B)$
T	T	0.0007
T	F	0.0111
F	T	0.0003
F	F	0.9879

$$P(M) = \alpha f_{11}(M)$$

$f_{11}(M) =$

M	$f_{11}(M)$
T	0.0117
F	0.9883

$$\alpha = \frac{1}{\sum_M f_{11}(M)} = 1$$

$$\therefore \boldsymbol{P(m) = 0.0117}$$

b. $P(a, j, m)$

$$P(a, j, m) = \sum_B \sum_E P(B, E, a, j, m)$$

$$= P(e, b, a, j, m) + P(e, \neg b, a, j, m) + P(\neg e, b, a, j, m) + P(\neg e, \neg b, a, j, m)$$

$$= p(e)\, p(b)\, p(a|b, e)\, p(j|a)\, p(m|a) + p(e)\, p(\neg b)\, p(a|\neg b, e)\, p(j|a)\, p(m|a)$$
$$+ p(\neg e)\, p(b)\, p(a|b, \neg e)\, p(j|a)\, p(m|a)$$
$$+ p(\neg e)\, p(\neg b)\, p(a|\neg b, \neg e)\, p(j|a)\, p(m|a)$$

$$= 0.002\times0.001\times0.95\times0.9\times0.7 + 0.002\times0.999\times0.29\times0.9\times0.7$$
$$+ 0.998\times0.001\times0.94\times0.9\times0.7 + 0.998\times0.999\times0.001\times0.9\times0.7$$

$$\boldsymbol{P(a, j, m) = 0.0016}$$

c. $P(b|\neg m)$

$$P(b|\neg m) = \frac{P(b, \neg m)}{p(\neg m)}$$

$$P(b, \neg m) = \sum_A \sum_E \sum_J P(b, E, A, J, \neg m)$$

$$= P(e, a, j, b, \neg m) + P(e, a, \neg j, b, \neg m) + P(e, \neg a, j, b, \neg m) + P(e, \neg a, \neg j, b, \neg m)$$
$$+ P(\neg e, a, j, b, \neg m) + P(\neg e, \neg a, j, b, \neg m) + P(\neg e, a, \neg j, b, \neg m)$$
$$+ P(\neg e, \neg a, \neg j, b, \neg m)$$

$$= p(e)\, p(a|b, e)\, p(j|a)\, p(b) p(\neg m|a) + p(e)\, p(a|b, e)\, p(\neg j|a)\, p(b) p(\neg m|a)$$
$$+ p(e)\, p(\neg a|b, e)\, p(j|\neg a)\, p(b) p(\neg m|\neg a)$$
$$+ p(e)\, p(\neg a|b, e)\, p(\neg j|\neg a)\, p(b) p(\neg m|\neg a)$$
$$+ p(\neg e)\, p(a|b, \neg e)\, p(j|a)\, p(b) p(\neg m|a)$$
$$+ p(\neg e)\, p(\neg a|b, \neg e)\, p(j|\neg a)\, p(b) p(\neg m|\neg a)$$
$$+ p(\neg e)\, p(a|b, \neg e)\, p(\neg j|a)\, p(b) p(\neg m|a)$$
$$+ p(\neg e)\, p(\neg a|b, \neg e)\, p(\neg j|\neg a)\, p(b) p(\neg m|\neg a)$$

$$= (0.002\times0.95\times0.90\times0.30 + 0.002\times0.95\times0.1\times0.3 + 0.002\times0.05\times0.05\times0.99$$
$$+ 0.002\times0.05\times0.95\times0.99 + 0.998\times0.94\times0.90\times0.3$$
$$+ 0.998\times0.06\times0.05\times0.99 + 0.998\times0.94\times0.1\times0.3$$
$$+ 0.998\times0.006\times0.95\times0.99)\times0.001$$

$$P(b, \neg m) = 0.0002907007$$

$$P(b|\neg m) = \frac{P(b, \neg m)}{P(\neg m)} = \frac{0.0002907007}{0.9883} = \mathbf{0.0002941 \approx 0.0003}$$

d. $P(b|m, j)$

$$P(b|m, j) = \frac{P(b, m, j)}{P(m, j)}$$

$$P(b, m, j) = \sum_E \sum_A P(E, A, b, m, j)$$

$$= P(e, a, b, m, j) + P(e, \neg a, b, m, j) + P(\neg e, a, b, m, j) + P(\neg e, \neg a, b, m, j)$$

$$= p(e)\ P(b)P(a|b, e)\ p(j|a)\ p(m|a) + p(e)\ P(b)P(\neg a|b, e)\ p(j|\neg a)\ p(m|\neg a)$$
$$+ p(\neg e)\ P(b)P(a|b, \neg e)\ p(j|a)\ p(m|a)$$
$$+ p(\neg e)\ P(b)P(\neg a|b, \neg e)\ p(j|\neg a)\ p(m|\neg a)$$

$$= 0.002 \times 0.001 \times 0.95 \times 0.9 \times 0.7 + 0.002 \times 0.001 \times 0.05 \times 0.05 \times 0.01$$
$$+ 0.998 \times 0.001 \times 0.94 \times 0.9 \times 0.7 + 0.998 \times 0.001 \times 0.06 \times 0.05 \times 0.01$$
$$P(b, m, j) = 0.00059224259$$

$$P(m, j) = P(b, m, j) + P(\neg b, m, j)$$
$$P(\neg b, m, j) = P(e, a, \neg b, m, j) + P(e, \neg a, \neg b, m, j) + P(\neg e, a, \neg b, m, j)$$
$$+ P(\neg e, \neg a, \neg b, m, j)$$

$$= p(e)\ P(\neg b)P(a|\neg b, e)\ p(j|a)\ p(m|a) + p(e)\ P(\neg b)P(\neg a|\neg b, e)\ p(j|\neg a)\ p(m|\neg a)$$
$$+ p(\neg e)\ P(\neg b)P(a|\neg b, \neg e)\ p(j|a)\ p(m|a)$$
$$+ p(\neg e)\ P(\neg b)P(\neg a|\neg b, \neg e)\ p(j|\neg a)\ p(m|\neg a)$$

$$= 0.002 \times 0.999 \times 0.29 \times 0.9 \times 0.7 + 0.002 \times 0.999 \times 0.71 \times 0.05 \times 0.01$$
$$+ 0.998 \times 0.999 \times 0.001 \times 0.9 \times 0.7 + 0.998 \times 0.999 \times 0.999 \times 0.05 \times 0.01$$
$$= 0.00149185764$$

$$P(m, j) = 0.00059224259 + 0.00149185764 = 0.00208405764$$

$$P(b|m, j) = \frac{P(b, m, j)}{P(m, j)}$$

$$P(b|m, j) = \frac{0.00059224259}{0.00208405764} = \mathbf{0.2842}$$

2. *Use SamIam to construct the Bayesian network in Part I and then answer the following queries.*

Bayes network

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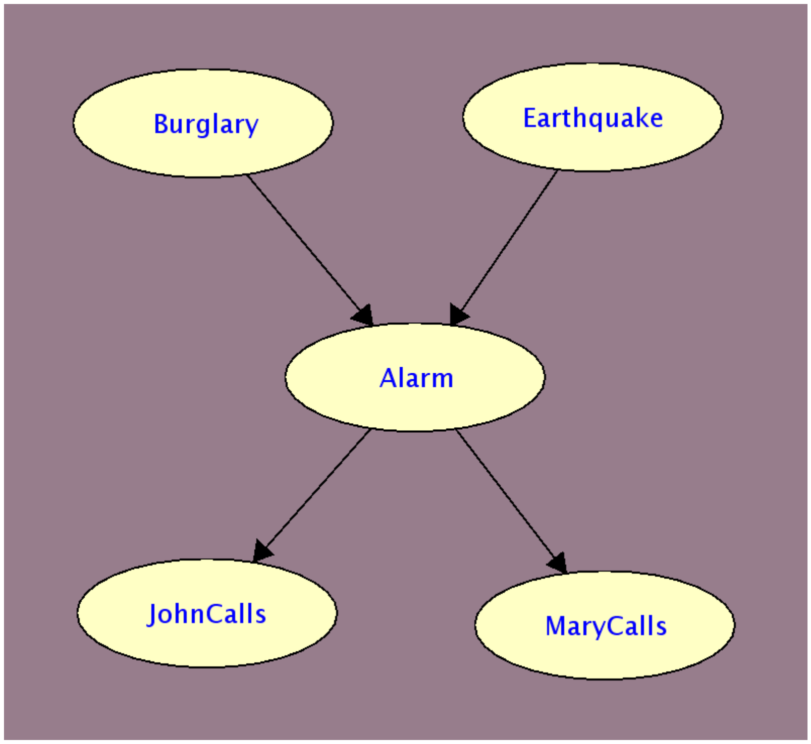
HOME WORK 2



Algorithm used shenoy-shafer

a. $P(m) -$ 0.0117
b. $P(a, j, m) -$ 0.0016
c. $P(b|\neg m) -$ 0.0003
d. $P(b|m, j) -$ 0.2842
e. $P(b|e, j, m) -$ 0.0033
f. $P(j|m) -$ 0.1776
g. $P(e|m, j) -$ 0.1761
h. $P(e|a, m, j) -$ 0.2310

3. How did I search?

I used Google Scholar to find the papers related to application of Bayesian Network for Classification. I found few articles related to classification, looked up their references and citations, related articles for more papers on classification and Bayesian Network. I checked the number of citations for each those papers and picked the ones with most citations.

One Page summary

Why did I choose this paper?

I have done a project on handwritten letter classification as a part of machine learning course work. For that project we have used a pre extracted feature set and I was fascinated to know about the process of feature extraction. This paper gives an overview of various feature extraction methods.

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HOME WORK 2

Performance of Hidden Markov Model and Dynamic Bayesian Network classifiers on handwritten Arabic word recognition

The authors of the paper claim to compare the performance of Hidden Markov Model and Dynamic Bayesian Network for recognizing handwritten Arabic words. They employed a 3 stage pipeline for this task. The stages include preprocessing, feature extraction and classification.

Preprocessing convert the paper document to binary images, segmenting lines, words, and estimate the baselines. Each word was convert to an image. All the images were normalized to have a height of 45 pixels, a mirrored image of the preprocessed image is fed into the feature extraction stage. The paper mentions that the mirrored images would speed up the training and testing process, but does not specify the reason for it.

A sliding window approach is adopted to extract the statistical features such as the number of dark pixels. The mirrored image was horizontally divided into 15 frames of equal height. The sliding window has a height of 45 pixels and a width of 3 pixels with an overlap of 1 pixel. A total of 30 features are extracted for each sliding window. 15 features from each window region representing the proportion dark pixels with in that region. 1 feature representing the proportion of dark pixels in the window is calculated and rest of the 14 features are calculated as the sum of every pair of consecutive features from the 15 features extracted earlier.

A left to right Bakis topology HMM is used in this work. The parameters of HMM are randomly initialized and later optimized with Baum- Welch iterative optimization algorithm by optimizing observation sequence probability. Auto regressive coupled model is adopted for dynamic Bayesian network, the parameters of DBN are learned through EM approach.

The performance of HMM and DBN is evaluated on IFN/ENIT database containing 32,492 Arabic handwritten words. 80% of the data was used for training with cross validation and testing is performed on the remaining 20% of the data.

The results show that HMM has achieved 82% accuracy where as DBN has achieved 66% accuracy, but the reasons for HMM outperforming DBN are not clearly mentioned or discussed. They specify the probable reason behind the poor performance of DBN is due to the conversion of recognition problem into linear case though the feature extraction process as DBN is good at modelling non linear cases and HMM works well for the linear cases.

The language of the paper is good but, a comprehensive discussion of the results would have been much appreciated.

1.Dynamic Bayesian Network for Vehicle Classification in Video

The paper proposes an application of DBN for determining the class of a vehicle given its rear side view. The authors consider using simple low level features such as height, width and angle of photography instead of high level features such as SIFT, yet obtaining a high accuracy.

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HOME WORK 2

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2.A Probabilistic Associate Model for Segmenting Weakly Supervised Images

The paper proposes a novel technique of learning semantic associations between super pixels through hierarchical Bayesian network for weakly supervised image segmentation. The experimental results demonstrate that their method achieves better results than other state of the art weakly supervised segmentation algorithms and performs reasonable compared to fully supervised segmentation.

Citations

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3.Vehicle Detection in Aerial Surveillance using Dynamic Bayesian Networks

The paper uses Dynamic Bayesian Network to detect vehicles in aerial images, the DBN is trained on the local features extracted for each pixel considering its neighborhood. The experimental results demonstrate that the proposed method produces less false positives than existing MVDRD, Cascade Classifiers, Symmetric Properties.

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4.An Expert System for Detection of Breast Cancer Using Data Preprocessing and Bayesian Network

The paper studies the effect of dimension reduction on the classification. Authors use ReliefF algorithm for dimensionality reduction of the database, use Bayesian network for classification. The performance of Bayesian network is compared with Neural Network, Neural Network combined with Association Rules. In their experiment results Bayesian Network achieved an accuracy of 98.1% which is the best compared to NN and NN+AR.

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5.Performance of Hidden Markov Model and Dynamic Bayesian Network classifiers on handwritten Arabic word recognition

This work compares the performance of HMM and DBN for Arabic word recognition. A pipeline of preprocessing, feature extraction and classification is employed to classify Arabic words from IFN/ENIT database. The statistical features are extracted though sliding window mechanism. The experimental results shows that HMM outperforms DBN in terms of accuracy, training, and testing times.

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6.Premature Ventricular Beat Classification Using Dynamic Bayesian Network

The paper studies the application of DBN and BN to classify heart beats in long term ECG records. The authors claim that the DBN achieves better results than BN as it accounts for the temporal relationships.

Citations:

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7.Event Detection and Summarization in Soccer Videos Using Bayesian Network and Copula

This work studies the application of Bayesian Network for automatic detection of events such as goal, goal attempt, card foul etc. in soccer videos. The primary contribution of this study is the use of Copula and Chow-Liu tree for calculating joint distributions in Bayesian Network that enables the use of more complicated distribution models for network variables.

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8.Toward Comprehensible Software Fault Prediction Models Using Bayesian Network Classifiers

The authors claim that they try to address the question of whether to consider comprehensibility, computational efficiency along with the predictive performance of the software fault detection system. They compare 15 Bayesian network learners in terms of Area Under ROC and H-measure. The results show that all of those factors should be taken into consideration. Further more, the authors studied the applicability of Markov Blanket for feature selection, they found out that the MB was able to reduce the number of features with out affecting the performance.

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9.Facial Emotion Detection Considering Partial Occlusion of Face Using Bayesian Network

The paper proposes an application of Bayesian network for emotion detection with facial features considering the partial occlusion. The results show that the Bayesian Network was able to achieve high recognition rates.

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10.Multi-label classification with Bayesian network-based chain classifiers

The paper discusses an application of chain of Bayesian Networks for multi-label classification. The authors experimented with different base classifiers and found that Naïve Bayes as base classifier of BCC was able to produce competitive results compared to multi dimensional Bayesian networks.

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