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MR Image texture analysis applied to the diagnosis of Alzheimer's Disease

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Abstract

Chapter 1

Introduction

In this report we will examine MRI data of the hippocampus using image texture analysis and apply machine learning. We have XX normal controls and XX Alzheimer's Disease (AD) patients. They are split into a training set (XX control and XX AD) and a test set (XX control and XX AD).

We will be using two different texture analysis on the data, XX and the gray level co-occurrence matrix (GLCM). We will calculate the GLCM using two different methods, one in 2D that that runs along the z-axis with angel 90 and distance 1 (Change depending on the results, and more research might include multiple angles).Castellano [2] The other method is calles voxel-based GLCM in 3D**FiXme Note: citation** space (VGLCM-TOP-3D), and is from the paper Voxel-Based Texture Analysis of the Brain (indsæt biblografi). We want to see if there is a difference between diagnostising a AD succesfully, by calculating the co-occurence matrix in 3D compared to 2D, and how well the GLCM methods work compared to XX. To do that we will use two different machine learning methods, k-NN and Gaussian mixture, based on each of the image texture models.

FiXme Note: citation

We will also try to replicate the analysis from MRfreeborough [1] and meanwhile tell if we can get better accuracy

1.1 Problem Definition

Is it possible to classify MRI data of the hippocampus into groups of healthy controls vs Alzheimer's patient, using a predefined set of image texture metrices, with an accuracy greater than 80%?**FiXme Note: Mere i intro. Måske 3D vs 2D**

FiXme Note: Mere i intro. Måske 3D vs 2D

1.2 Alzheimer's Disease

About 70% of the risk is believed to be genetic, where other factors include head injuries, depression or hypertension. Magnetic [3] **FiXme Note: Mere til AD**

FiXme Note: Mere til AD

Chapter 2

Data

Chapter 3

Method

3.1 Image texture analysis methods

3.1.1 Co occurrence matrix

Co occurence matrix is defined over an image to be the distribution values at a given offset.[4] Bharati

With the co occurence matrix, we have matrix **C** defined over an $n \times m$ image, with $\Delta x, \Delta y$ being the parameterized offset, so

$$C_{\Delta x, \Delta y}(i,j) = \Sigma_{p=1}^{n} \Sigma_{q=1}^{m} \begin{cases} 1, & \text{if } I(p,q) = i \text{ and } I(p+\Delta x, q+\Delta y) = j \\ 0, & \text{otherwise} \end{cases}$$

3.2 Machine learning methods

3.2.1 K-nearest neighbors algorithm

k-NN for short is a method that is used for classification and regression. Where the output is a class and member of this class, and this object is classified by its neighbors. For instance, if we chose k to 1, then the object will be assigned to the class of the single nearest neighbor.

The algorithm consist of training examples, that are vectors in multidimensional space, with each its label. The most used distance metric is Euclidean distance.

The drawback of k-NN is that classification can be skewed in that way, that the more frequent class tend to dominate the prediction of new examples, because they tend to be common among the k-NN due to their large number.

The way we wish to implement the k-NN in matlab is, first we handle the data, then we will calculate the distance between two data instances and after that, we can locate k most similar data instances and generate a response from a set. After all this is done, we have to summarize the accuracy of predictions.

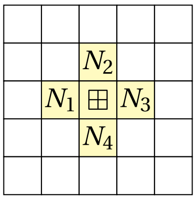
Dette vil være en lille introduktion til de tools vi bruger til at analysere vores data med. Da vores data er MRI skanninger af hjernen, som er nogen voxels[1] som bliver repræsenteret i 3D.

3.3 Erode

Normalt brugte man dette til binære billeder, men senere hen er det udvidet til også at omfatte grayscale billeder. Grunden til at dette bruges er for at fjerne støj på billedet.

Vi bruger Erode på vores MRI scanning, da der kan være gray-bit mix og derfor fjerner overflydig og blandet data. Hvis vi starter på hvordan 2D virker, så

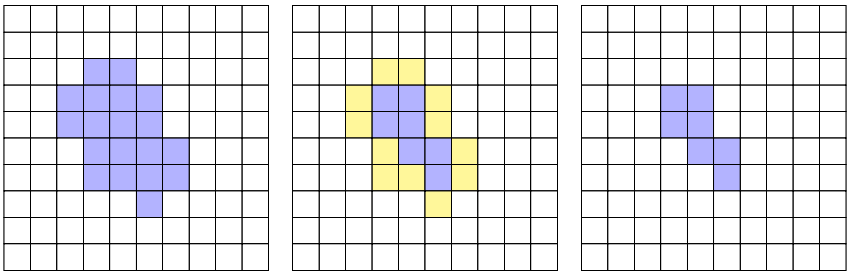
For at illustrere hvordan erosion virker, gør vi det på et 2D plan, betragt figur 3.1, hvor vi bruger et plus til at fjerne støj.



Erosion2D

Figure 3.1: Text

Så med figur 3.1, bruger vi denne på figur 3.2.



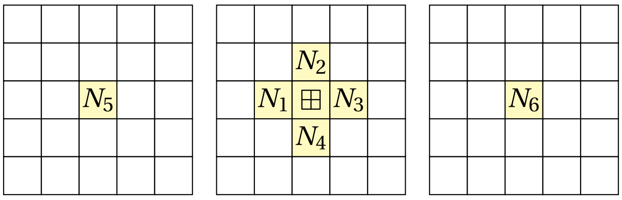
rosionExample

Figure 3.2: Left: Middle: Right:

Således er støjen nu fjernet. Vi vil udvide dette til 3D, da vores MRI er i 3D. Som det ses på figur 3.1 har denne 4 naboer den tjekker, når man udvider til 3D, får vi 2 nye naboer, dvs 6 naboer i alt. Hvis en af dem er udenfor den ønskede matrix, ekskluderes pixlen.

Da vores data er i 3D, så i udvider vi erosion, hvor det stadig er et plus, men med 2 ekstra naboer Now we expand this cross for the 3D and its the same concept for 3D. Now it 6 neighbours instead of 4, where we expand it for the 3D

[1] noget her



Erosion3D

Figure 3.3: Text

3.4 Image texture (Co-occurrence)

Et image texture er bare et sæt af metricer? som udregnes for at opfatte texturen på et billede. Image textures giver os denne information.

Der findes flere approaches til hvordan man udregner image textures, vi bruger den statistiske vej. Helt specifikt udregner vi en co occurence matricer, hvor man kan få en del numeriske features fra gray tones. Disse kan ses i appendix A på s. 13.

derivativefeatures derivativefeatures

Hvordan vi har 256x256 matrix, med en distance på δ og angles θ, hvor $\delta = \{1, 2, \ldots, 10\}$ og $\theta = \{0°, 45°, 90°, 135°\}$.

Ud fra denne GLCM matrix så kan vi udregne textural features fra de 100 GLCM af MRI grayscale image data set.

Snakke om hvordan den fungere, med distance og grader

3.5 Principal Component analysis

3.5.1 Application to images

3.6 K-nearest neighbors

3.6.1 Cross validation

Image texture PCA Principal Component Analysis Application to images Machine learning (Knn, Ann, Gaussian)

noget tekst

noget mere tekst **FiXme Note: en note**

endnu mere tekst

og til slut mere tekst **FiXme Error: en fejl**

FiXme Fatal: her er noget galt
FiXme Note: en note
FiXme Warning: en advarsel – noget er helt forkert
FiXme Error: en fejl

Chapter 4

Implementation

Chapter 5

Result

Chapter 6

Discussion

Nogen angle og planes er ens

Når vi loader ind i en train og test, så

Chapter 7

Conclusion

Appendices

Appendix A

Co occurrence matrix derivation features

ationfeatures

$$C_x(i) = \sum_{j=1}^{N} C(i,j)$$

$$C_y(i) = \sum_{i=1}^{N} C(i,j)$$

$$C_{x+y}(k) = \sum_{\substack{i=1 \\ i+j=k}}^{N} \sum_{j=1}^{N}, \quad \text{k = 2, 3, ... , 2N}$$

$$C_{x+y}(k) = \sum_{\substack{i=1 \\ |i-j|=k}}^{N} \sum_{j=1}^{N}, \quad \text{k=0,1,...,N-1}$$

$$f_1 = \sum_{i=1}^{N} \sum_{j=1}^{N} \{C(i,j)\}^2 \tag{A.0.1}$$

AngularSecond

$$f_2 = \sum_{n=0}^{N-1} n^2 \left\{C_{x+y}(k)\right\} \tag{A.0.2}$$

Contrast

$$f_3 = \frac{\sum_{i=1}^{N} \sum_{j=1}^{n} ijC(i,j) - \mu_x \mu_y}{\sigma_x \sigma_y} \tag{A.0.3}$$

Correlation

$$f_4 = \sum_{i=1}^{N} \sum_{j=1}^{N} (i-\mu)^2 C(i,j) \tag{A.0.4}$$

Variance

$$f_5 = \sum_{i=1}^{N} \sum_{j=1}^{n} \frac{1}{1+(i-j)^2} C(i,j) \tag{A.0.5}$$

InverseDiffer

$$f_6 = \sum_{i=2}^{2N} i C_{x+y}(i) \tag{A.0.6}$$

SumAverage

$$f_7 = \sum_{i=2}^{2N} (i-f_6)^2 C_{x+y}(i) \tag{A.0.7}$$

SumVariance

$$f_8 = \sum_{i=2}^{2N} C_{x+y}(i) \log(C_{x+y}(i)) \tag{A.0.8}$$

SumEntropy

$$f_9 = -\sum_{i=1}^{N} \sum_{j=1}^{N} C(i,j) \log(C(i,j)) \tag{A.0.9}$$

Entropy

$$f_{10} = \text{variance of } C_{x-y} \tag{A.0.10}$$

DifferenceVar

$$f_{11} = -\sum_{i=0}^{N-1} C_{x-y}(i) \log(C_{x-y}(i)) \tag{A.0.11}$$

DifferenceEnt

Bibliography

MRfreeborough [1] Peter A. Freeborough & Nick C. Fox. Mr image texture analysis to the diagnosis and tracking of alzheimer's disease. *IEEE*, 17(3):5, June 1998.

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Magnetic [3] Stephane Lehericy & Malgorzata Marjanska & Lilia Mesrob & Marie Sarazin & Serge Kinkingnehun. Magnetic resonance imaging of alzheimer's disease. *Springer Verlag*, 17(3):5, June 2005.

Bharati [4] Image texture analysis: methods and comparisons. Manish h. bharati, j. jay liu, john f. macgregor*. *Department of Chemical Engineering*, page 15, February 2004.