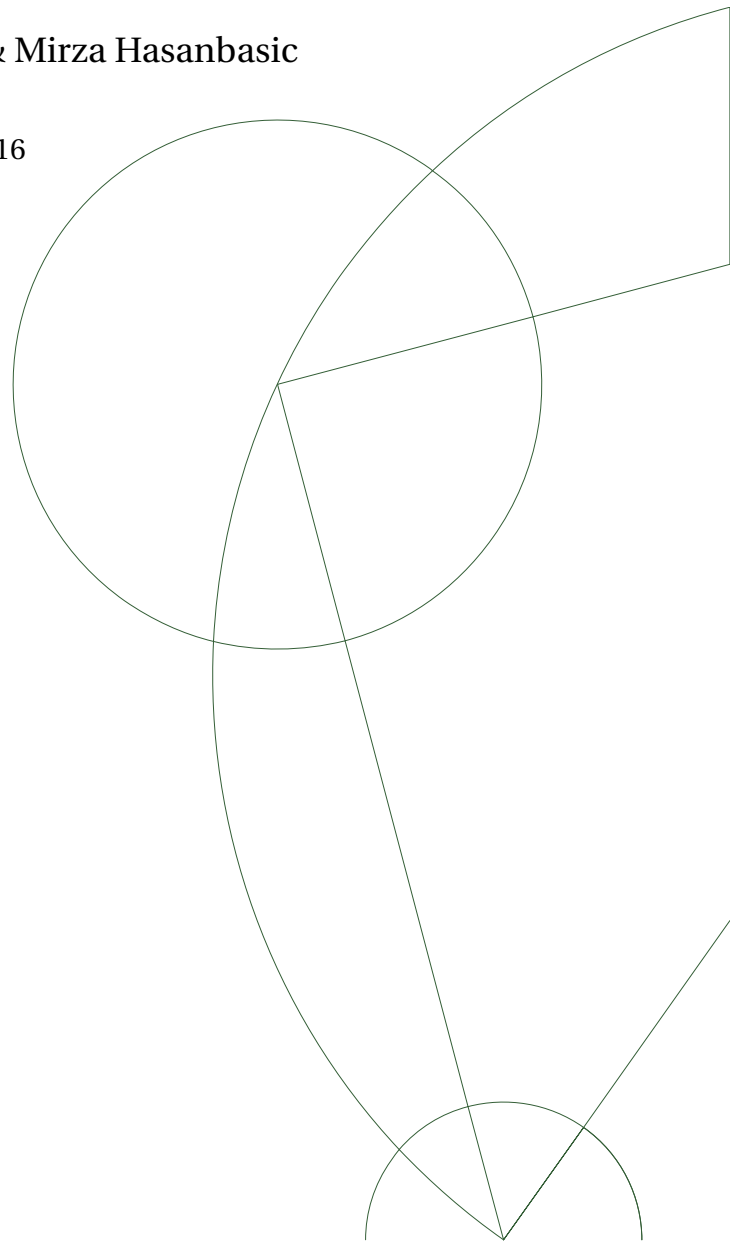# MR Image texture analysis applied to the diagnosis of Alzheimer's Disease

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Abstract

Chapter 1

Introduction

Alzherimer's Disease (AD) is the most common cause of dementia among people and is a growing problem in the aging populations. It has a big impact on health services and society as life expectancy increases.**FiXme Note: Hvorfor** AD is the cause in about 60%-70% of all cases of dementia [1] and about 70% of the risk is believed to be genetic [2]. Currently there are no way to cure dementia or to alter the progressive course. But however, much can be done to support and improve the lives if AD is found in the early stage of progression [1]

In this report we will examine MRI data of the hippocampus using image texture analysis and apply machine learning, for this we have 50 normal controls and 50 Alzheimer's Disease (AD) patients.

We will be using two different image texture analysis method, one which will me in 2D[3][4] and the other one will be in 3D[5], from which we calculate the data to the gray level co-occurrence matrix (GLCM).

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%?

Will there be a difference in diagnosing AD successfully by calculating the co-occurence matrix in 3D compared to 2D.

Chapter 2

Data

Chapter 3

Method

3.1 Image texture analysis methods

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.

3.1.1 Co occurrence matrix

The co-occurence matrix is a method to measure the greyscale intensity (GI) of an image, it is defined as the distribution values at a given offset. The element (i,j) in the co-occurence matrix, **C**, over an image $n \times m$, with $\Delta x, \Delta y$ being the parameterized offset, is calculated by

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

FiXme Note: find reference The element (5,4) can therefore be translated to meaning how many times is there an element in the image with greyscale **FiXme Note: level or intensity?** intensity 5 and another element offset $\Delta x, \Delta y$ from the originial with greyscale intensity 4, i.e. if the offset is 1,0 and the first element is (x,y) (4,3) with intensity 5 it would mean that element (x,y) (5,3) would have GI 4.

The co-occurrence matrix is quadratic with the number of rows and columns equal to difference between the largest and smallest greyscale intensity, for example if we have greyscale intensities varying between 0 and 256 we get a 256×256 co-ocurrence matrix.

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. 14. Hvordan vi har 256x256 matrix, med en distance på δ og angles θ, hvor $\delta = \{1, 2, ..., 10\}$ 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

3.2 Machine learning methods

3.2.1 Crossval

3.2.2 Feature selection

Forward feature selection

Naive

3.2.3 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.
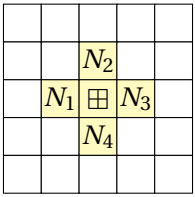
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[1]noget her
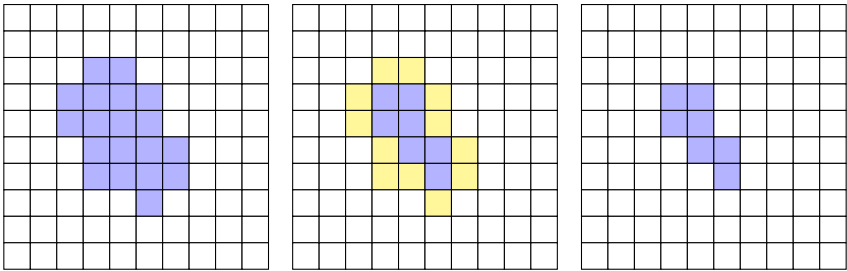
Figure 3.1: Text

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

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, eksluderes 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
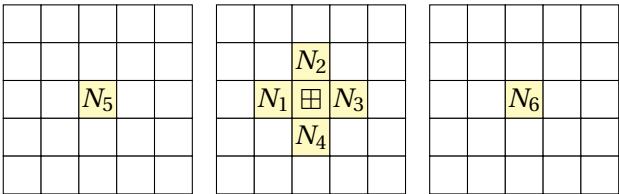

Figure 3.3: Text

3.4 Principal Component analysis

3.4.1 Application to images

3.5 K-nearest neighbors

3.5.1 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

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

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

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

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

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

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

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

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

`DifferenceVar`

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

`DifferenceEnt`

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