**Veterinary Thermographic Image Analysis**

**Preprocessing of Thermographic Images of** **Chiari Malformation / Syringomyelia Using CVIP-FEPC**

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# **ABSTRACT**

Thermographic imaging techniques produce images whose pixel values represent the temperature distribution of an object. Here thermographic image data from 19º C to 40º C was linearly remapped to create images with 256 gray level values. Further a single band (green band) from these remapped images was extracted to avoid the out of range temperature value in few images as well as for the fast processing of results. Features were extracted from these images, including histogram and texture features. Various pattern classiﬁcation algorithms have performed well in thermographic image classiﬁcation problems such as k-nearest neighbor, SoftMax scaling and the comparison metrics such as Euclidean metric. Here total of 195 images are considered and same set of experiment was performed on both 18-color images and remapped images having same number of classes. The difference between the success rates of 18 color images and temperature remapped images is below 10% which does not provide any distinct contrast between them. Due to the poor results, it was found the need of preprocessing to the remapped images using gray level quantization method with 32 gray levels and 64 gray levels. Further experiments will be done with larger image datasets, new set of features and gray level quantization methods for determination of more accurate results.

# **INTRODUCTION**

Chiari malformations is a condition where the cerebellum of the brain is structurally defected and has highly heritable neurological disorders. These neurological disorders result from a different malformations of the occipital bone of the canine skull. It is believed that Chiari malformation were identified in the breed Cavalier King Charles Spaniels. According to the resources, almost 95% of Cavalier King Charles Spaniels have Chiari malformation, however any type of symptoms can be found in only a quarter of these dogs. The cause of Chiari-like malformation is not fully understood, but is thought to be hereditary in some breeds. A Chiari-like malformation (caudal occipital malformation syndrome) is a condition that retards the growth of the hollow places in dog’s skull, making the posterior fossa too small or deformed. This causes **Syringomyelia**, which is the compression of the brain. Researchers estimate that more than 50% of cavaliers may have Syringomyelia. The severity and extent of Syringomyelia also appear to get worse in each succeeding generation of cavaliers. It is worldwide in scope and not limited to any country, breeding line, or kennel, and experts report that it is believed to be inherited in the cavalier. This disease not only affects thousands of dogs, but over three hundred thousand children are affected yearly with similar condition. Therefore, canines are an appropriate model for the treatment of the human condition.

In the veterinary field, the thermographic images of canines of breed Cavalier King Charles Spaniel are taken into consideration to investigate the extent of Chiari malformation or COMS pathology. Several patterns of the images are used to develop pattern classification algorithm to classify absent, mild, moderate and severe classes of the pathology. These information makes easier for us to identify the normal and abnormal dogs. In this study, the thermographic images of canines of the breed Cavalier King Charles Spaniel are used to investigate Syringomyelia pathology.

## Objectives and Strategy

The primary objective of this project is to detect and classify Syringomyelia in canines with better outcomes. The following points can be summarized as the objectives of the study:

1. Experiment the images with preprocessing using CVIP-FEPC for both 18-color images and the remapped images.
2. Compare and analyze the results from both 18-color images and the remapped images.
3. Investigate if any preprocessing is necessary or not.

# **BACKGROUND**

Veterinary medical practice uses several imaging techniques such as radiology, computed tomography (CT), and magnetic resonance imaging (MRI) for diagnosis. But, harmful radiation involved during imaging, expensive equipment setup and excessive time consumption are major drawbacks of these techniques [1]. Medical science considers temperature as one of the major health indicators. As per medical thermography, the presence of disease may alter the thermal patterns of the skin surface [2] and here we investigate the potential correlation between skin temperature patterns and certain pathological conditions. Thermographic imaging captures infrared radiation to produce images whose pixel values are mapped into appropriate colors that represent the temperature distribution. It will capture the thermal patterns on the body surface which can indicate various underlying pathologies. With thermography, the imaging process is similar to taking a photograph with a standard camera, which alleviates the time and sedation issue. Also, it addresses the shortcomings of the existing imaging systems as it is a noninvasive technique that avoids harmful radiation and is less expensive in terms of cost and time [3].

Because of its noninvasive and inexpensive nature, the use of thermographic imaging, or infrared imaging, has been increasing as a clinical diagnostic tool in both veterinary and human medicine in recent years. Several research and development was continuously done in thermographic images of canines to investigate Chiari malformation, or COMS pathology. In the past, pattern classification algorithm was developed for; severe, moderate and mild classes of the pathology for cerebellar herniation and kinking of medulla. The front of head (A1), and top of head (A1D) images were used. After an initial set of experiments, K-nearest Neighbor with K=3, distance metric: Euclidean for classification method and distance metric, Histogram and Texture features and Soft-max with r=1 for data normalization method was determined to be useful for the final experiments. With these set of parameters, it was believed that the 89% and 97% classification success indicates that the top and front of head are the most useful for differentiation of the two classes and similarly the texture correlation and histogram energy features appear the most predictive [4].

For this particular research, irrespective of the number of classes used in previous researches, the image set is classified into syrinx and no syrinx class to investigate the extent of Syringomyelia in canines.

# **MATERIALS AND METHODS**

## 1.1 Thermographic Images

In this project, a total of 195 thermographic images with top of head (A1D) view are considered. The images are divided into two categories: **Syrinx** and **NoSyrinx** classes for the pathology having 137 and 58 images respectively. The masks for all these images have been also collected. These images are provided by Long Island Veterinary Specialists (LIVS).

## 1.2 Software tools used

The software tools include CVIPtools, Computer Vision and Image Processing Feature Extraction and Pattern Classification (CVIPFEPC) that were developed at Computer Vision and Image Processing (CVIP) lab of Southern Illinois University at Edwardsville (SIUE). The Other software tool used is the COMPIX WinTes2 Meditherm software which allows us to save the captured image in different color maps. For this particular study, the 18 color Meditherm images are remapped to 256-graylevel image from 19° C to 40° C as this temperature range covers the entire range of the body temperature of canines.

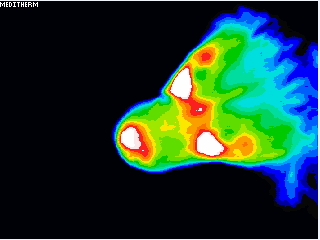
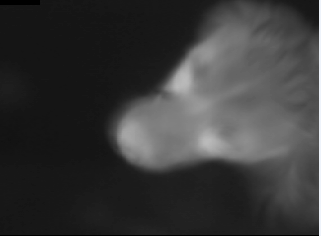
 

Figure :18 color Meditherm image Figure : 256-graylevel image

## 1.3 Experimental Methods

The following are the classification method and distance metric, set of features and data normalization method used;

*CLASSIFICATION METHOD AND DISTANCE METRIC*

* K-Nearest Neighbor with K = 3, distance metric: Euclidean

*FEATURES*

* Histogram features: Mean. Standard deviation, Skew, Energy and Entropy
* Texture features: Energy, Inertia, Correlation, Inverse difference, and Entropy. The texture distance is 6.

*DATA NORMALIZATION METHOD*

* Soft-max with r=1

# **EXPERIMENTAL SETS**

A series of experiments are done on the thermographic images of Chiari malformation. The experiments are divided into following five sets:

1. **Experiment 1**
   * Total number of images = 70
   * Randomly picked 35 images from both classes
   * Syrinx = 35
   * NoSyrinx = 35
2. **Experiment 2**
   * Total number of images = 195
   * Consists all images from both classes
   * Syrinx = 137
   * NoSyrinx = 58
3. **Experiment 3**
   * Total number of images = 116
   * Consists all images from NoSyrinx and randomly picked from Syrinx class
   * Syrinx = 58
   * NoSyrinx = 58
4. **Experiment 4**
   * Total number of images = 116
   * Consists all images from NoSyrinx and randomly picked remaining 58 from Syrinx class
   * Syrinx = 58
   * NoSyrinx = 58
5. **Experiment 5**
   * Total number of images = 70
   * Randomly picked 35 images in both classes
   * Syrinx = 35
   * NoSyrinx = 35

# **RESULT AND DISCUSSION**

The experiments are designed to calculate the success rate with temperature remapped and 18-color images in order to find the variation in results with the choice of image types. The temperature remapped images are converted through COMPIX software and only green band is extracted from it. In this research total of 195 images are used which are top of head view. With histogram and texture features and the classification algorithm listed above we found the difference rate between them is below 10% which does not give any significant result at this point. Below are the graphs and tables showing result and the success rate.

*Results from Experiment 1*

Figure : Result from top 5 values from both 18 color and temperature remapped images.

Figure : Result from top 5 values from temperature remapped and respective 18 color images

Figure : Result from top 5 values from 18 color and respective temperature remapped images

Table : Table showing the difference measure between 18 color and temperature remapped images

|  |  |  |  |
| --- | --- | --- | --- |
| **Highest success rates** | **18 color images** | **Temperature remapped** | **Difference measure** |
| 1 | 46 | 47 | 2% |
| 2 | 42 | 46 | 9% |
| 3 | 42 | 46 | 9% |
| 4 | 42 | 46 | 9% |
| 5 | 41 | 45 | 9% |

(The difference measure is calculated from the highest five results from both 18-color images and temperature remapped images.)

*Results from Experiment 2*

Figure :Result from top 5 values from 18 color and respective remapped values with same features.

Figure :Result from top 5 values from both 18 color and temperature remapped images.

Figure : Result from top 5 values from temperature remapped and respective 18 color images with same features.

Table : Table showing the difference measure between 18 color and temperature remapped images

|  |  |  |  |
| --- | --- | --- | --- |
| **Highest success rates** | **18 color images** | **Temperature remapped** | **Difference measure** |
| 1 | 137 | 135 | 1% |
| 2 | 136 | 134 | 1% |
| 3 | 135 | 132 | 2% |
| 4 | 135 | 132 | 2% |
| 5 | 134 | 131 | 2% |

(The difference measure is calculated from the highest five results from both 18-color images and temperature remapped images.)

*Results from Experiment 3*

Figure : Result from top 5 values from both 18 color images and temperature remapped images.

Figure : Result from top 5 values of temperature remapped images and respective 18- color images with same features

Figure : Result from top 5 values of 18 color images and respective temperature remapped images with same features

Table : Table showing the difference measure between 18 color and temperature remapped images

|  |  |  |  |
| --- | --- | --- | --- |
| **Highest success rates** | **18 color images** | **Temperature remapped** | **Difference measure** |
| 1 | 80 | 78 | 3% |
| 2 | 80 | 75 | 6% |
| 3 | 80 | 73 | 9% |
| 4 | 79 | 73 | 8% |
| 5 | 79 | 72 | 9% |

(The difference measure is calculated from the highest five results from both 18-color images and temperature remapped images.)

*Results from Experiment 4*

Figure : Result from top 5 values from both 18 color images and temperature remapped images.

Figure : Result from top 5 values of temperature remapped images and respective 18- color images with same features

Figure : Result from top 5 values of 18 color images and respective temperature remapped images with same features

Table : Table showing the difference measure between 18 color and temperature remapped images

|  |  |  |  |
| --- | --- | --- | --- |
| **Highest success rates** | **18 color images** | **Temperature remapped** | **Difference measure** |
| 1 | 79 | 77 | 3% |
| 2 | 79 | 76 | 4% |
| 3 | 78 | 76 | 3% |
| 4 | 77 | 76 | 1% |
| 5 | 77 | 75 | 3% |

(The difference measure is calculated from the highest five results from both 18-color images and temperature remapped images.)

*Results from Experiment 5*

Figure : Result from top 5 values from both 18 color and temperature remapped images.

Figure : Result from top 5 values from temperature remapped and respective 18 color images

Figure : Result from top 5 values from 18 color and respective temperature remapped images

Table : Table showing the difference measure between 18 color and temperature remapped images

|  |  |  |  |
| --- | --- | --- | --- |
| **Highest success rates** | **18 color images** | **Temperature remapped** | **Difference measure** |
| 1 | 50 | 52 | 4% |
| 2 | 50 | 52 | 4% |
| 3 | 50 | 51 | 2% |
| 4 | 50 | 50 | 0% |
| 5 | 49 | 50 | 2% |

(The difference measure is calculated from the highest five results from both 18-color images and temperature remapped images.)

# **SUMMARY AND CONCLUSION**

The main aim of this study is to investigate the possibilities of success rate with temperature remapped images compared with 18 color images in identification of Chiari malformation and Syringomyelia pathology in canines. Chiari malformation and Syringomyelia are mostly identified in the breed Cavalier King Charles Spaniels. Thus the thermographic images of the same breed provided by Long Island Veterinary Specialists (LIVS) has been considered in this project as well to examine the extent of Syringomyelia in canines. The 18 color Meditherm images provided by LIVS are remapped to 256-graylevel image from 19° C to 40° C with the help of COMPIX software. The first phase of experiment includes the preprocessing of the thermographic images using CVIP-FEPC on 18-color images and the second phase of experiment using remapped images.

The primary aim of this research study is to investigate the success rate from the experiments with 18-color images and remapped images. From the five sets of experiment, the difference rate between 18-color images and temperature remapped images is below 10% which does not indicate any significant difference between two images. The results are not as expected during the beginning of the study. At this point of stage, we cannot say either of the images results better for the classification of Syringomyelia pathology.

# **FUTURE WORK**

In this study, neither of the two - 18-color images and remapped images – has been able to give distinct results, when compared using the same parameters used in previous research, they gave similar results. In future we can run some experiments using new features other than histogram and texture that may work better to find significant results. It is also recommended to use several preprocessing methods to the images with different levels of gray level quantization and averaging filters with different mask sizes. We can preprocess the images for noise mitigation using 3x3 averaging filters (Gaussian and mean filters) and gray level quantization with 32 gray levels and 64 gray levels. Also the mask used in this experiment consist the entire head including parts of the ears, nose, muzzle, etc. So, in future we can run experiments with smaller masks that do not include ears, nose, muzzle, etc.

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