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ARTIFICIAL INTELLIGENCE APPLIED TO DETECTION OF MELANOMA

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Abstract

The results of applying artificial intelligence methods to diagnose skin tumors are described. The 1st-Class Fusion automatic induction software [1] was used to classify tumors based on a set of 16 features extracted from each tumor. Two hundred fity one skin tumor images were separated into a training set and a test set for the experiment.

Seventy percent of the malignant tumors in the test set were diagnosed correctly when sixty percent of the tumor images were used for training. When one class of tumors (the dysplastic nevi) was excluded, this success ratio grew to ninety-five percent. It was determined that the automatic induction software used primarily high-level features such as area, asymmetry and irregularity to induce the classification rules, although some lower-level features were also used. This provides an indication as to which features should be emphasized or excluded in future experiments.

Introduction

The incidence of malignant melanoma - the deadliest form of skin cancer - is now over 15 times higher than in the 1930s [2]. Medical costs are soaring, and skin biopsies have become the most frequently reimbursed Medicare procedure [3]. When diagnosed in time, melanoma is relatively easy to treat, and patients show survival rates near one hundred percent [2]. Automated diagnosis - if deemed feasible - may increase the chances of early detection and lower the cost of unnecessary biopsies. Computer vision methods have shown promise of good results when applied to the problem of skin tumor diagnosis in the past [4, 5, 6,7,8].

Materials and Methods

The images used in this research were digitized from 35-mm color slides obtained from a private dermatology practice and from New York University. The digital images had spatial resolution of 512x512 pixels, had a brightness resolution of 256 levels per color plane, and consisted of three color planes (Red, Green and Blue).

The software was written in the ANSI C programming language on SUN workstations running under the SunOS 4.1.3 operating system.

The features used in this experiment consisted of: Irregularity - a measure of the irregularity of the tumor border [5]; Asymmetry - a measure of the asymmetry of the tumor [4]; Variance of the Red, Green and Blue color components in the tumors - an indication of the tumor texture; The relative intensities of the three color components; Spherical coordinates - A color representation developed for detection of variegated coloring in skin tumors [8]; The coordinates of the IHS color transform; Elevation; and Area.

Most of the image features were extracted directly from raw image data via computer vision algorithms developed specifically for this application [5,6,7,8]. In the case of area and elevation, the features were estimated by a dermatologist by inspection of the slides.

The tumor images were separated into a training and a test set, which were randomly chosen. The sizes of these sets were varied. Ten experiments were run for each combination of training and test set sizes to ascertain the statistical validity of the results.

Induction is the process of producing a general classification algorithm from a set of specific examples [8]. The mechanism used in this research is based on an algorithm known as ID3. The ID3 algorithm is the induction engine of the 1st-Class software [1], and operates by generating decision trees based on the input examples. These decision trees are coded as rules in the C programming language and incorporated into the software developed to classify the tumors.

Results

The success rates in diagnosing melanoma in the test tumors are shown in figure 1. Moderate success was achieved, with seventy percent of the malignant tumors correctly classified when the size of the training set was sixty percent. The standard deviation for this case was less than five percent, and is also indicated in the figure.

For the second part of the experiment, all tumors that were dysplastic nevi were excluded. The first experiment was then repeated with features from the new set of 162 tumors. The success rates in diagnosing melanoma are summarized in figure 2. The success rates are significantly higher than for the first part of the experiment. For a training set size of sixty percent, the success rate for diagnosing melanoma was over ninety-five percent. The standard deviation was lower than three percent.

Discussion

The low standard deviation and the fact that the success ratio increased monotonically with increasing training set size, indicate that the results are reliable. The increased accuracy for part two of the experiment indicates that the presence of dysplastic nevi confused the automatic induction mecha-

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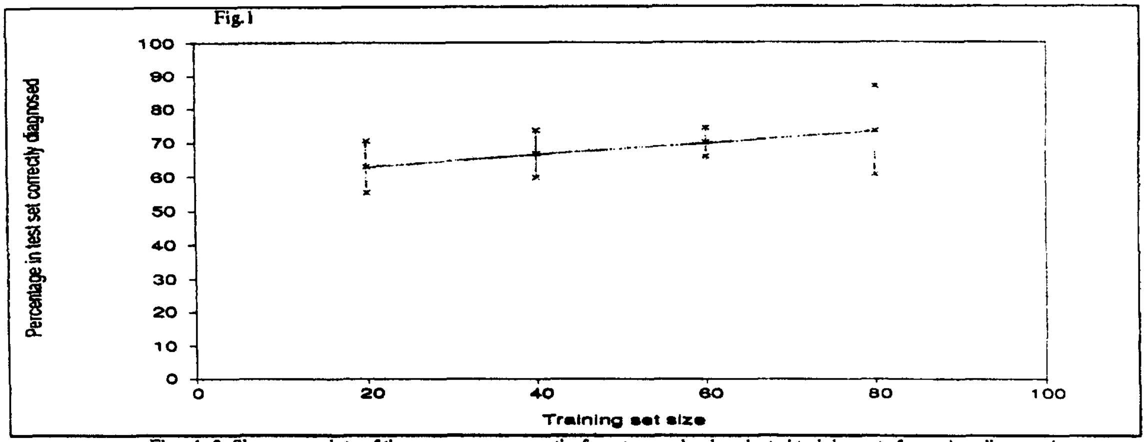
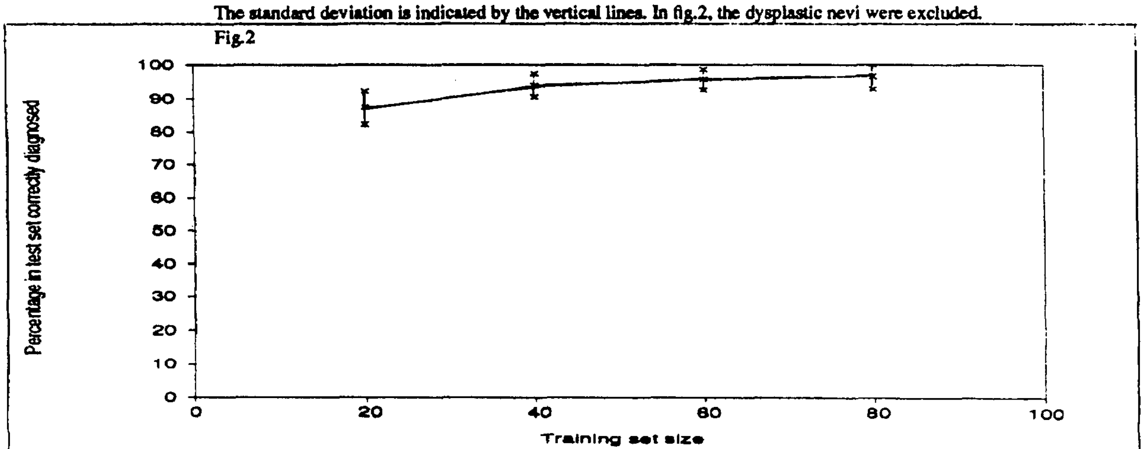


Figs. 1, 2. Shown are plots of the average success ratio from ten randomly selected training sets for each ordinate point. The standard deviation is indicated by the vertical lines. In fig.2, the dysplastic nevi were excluded.



nism. This is important, because it means that the diagnosis ratio can be significantly improved if an effective method can be found to rule out the dysplastic nevi.

Conclusions

This research has shown that features extracted from skin tumor images by computer vision methods can be reliable discriminators of malignant tumors from benign ones. Reliability was demonstrated by the monotonically increasing success ratios with increasing training set size and the small standard deviations from the mean success rates. The presence or absence of dysplastic nevi in the training and test sets was shown to have a dramatic impact on the effectiveness of the generated classification rules.

References

1. Thomas, W.; Hapgood, W. 1st-Class Fusion. 1st-Class Expert Systems, Inc., Wayland, Mass; 1987.
2. Silverberg, E. Cancer statistics. CA 35: 19-35; 1985.
3. Stoecker, W.V. and Moss, R.H. Digital imaging in dermatology. Editorial, Computerized Medical Imaging and Graphics. 16: 145-150; 1992.
4. Stoecker, W.V.; Li, W.W; Moss, R.H. Automatic detection of asymmetry in skin tumors. Computerized Medical Imaging and Graphics. 16: 191-197; 1992.
5. Golston, J.E.; Stoecker, W.V.; Moss, R.H. Automatic detection of irregular borders in melanoma and other skin tumors. Computerized Medical Imaging and Graphics. 16: 199-203; 1992.
6. Umbaugh, S.E.; Moss, R.H.; Stoecker, W.V. Applying artificial intelligence to the identification of variegated coloring in skin tumors. IEEE Eng. Med. Biol. 8(4): 43-52; 1989.
7. Umbaugh, S.E. Computer Vision in Medicine: Color metrics and image segmentation methods for skin cancer diagnosis. Ph.D. Dissertation, Electrical Engineering Department, University of Missouri - Rolla. UMI Dissertation Services. Ann Arbor, MI; 1990.
8. Umbaugh, S.E. ; Moss, R.H.; Stoecker, W.V. Automatic color segmentation of images with application to detection of variegated coloring in skin tumors. IEEE Eng. Med. Biol. 10: 57-62; 1991.