LASER PROGRAM

L.1 Statistical pattern recognition based diagnostic algorithms for autofluorescence diagnosis of oral cancer

A successful use of autofluorescence spectroscopy for cancer diagnosis requires an accurate and fast diagnostic algorithm that can best quantify the subtle but significant spectral differences between normal and abnormal human tissue. Development of such algorithms comprises of two major steps: (i) extraction of prominent features from the observed spectra by reduction of the dimensionality of the measured spectral variables, and (ii) classification of the diagnostic features by using the stored spectral database from histopathologically characterized tissues.

We have recently explored use of several state-of-the-art statistical pattern recognition based approaches to optimize both these aspects of algorithm development. For feature extraction, we used nonlinear maximum representation and discrimination feature (MRDF) approach to dimensionally reduce the input spectral data. A set of nonlinear transforms (polynomial mapping) was used to ensure that the output nonlinear features for cancerous and normal tissue were statistically best separated from each other in the reduced dimensionality space. These MRDF features were used as input to a traditional nearest mean classifier for classification. The results obtained using MRDF approach were significantly better compared to those obtained by use of the linear features (extracted using classical Principal Component Analysis (PCA) or Fisher's Linear discriminant (FLD)) as input to the same classifier [Lasers Surg. Med. 33, 48-56, 2003]. For supervised classification we have explored use of the theory of support vector machine (SVM). We developed a methodology that makes use of SVM for both feature extraction and classification jointly by integrating the newly developed recursive feature elimination (RFE) in the framework of SVM. This led to significantly improved classification results compared to that obtained when SVM was used in conjunction with features extracted using PCA. The integrated SVM-RFE approach was found to outperform the classification results yielded by FLD based algorithms. The best sensitivity and specificity values provided by the nonlinear SVM-RFE algorithm over the data sets investigated were 95% and 96% towards cancer for the training set data based on leave-one-out cross validation and 93% and 97% towards cancer for the independent validation set data [To appear in Journal of Biomedical Optics, 2005]. Though SVM-RFE algorithm provides very good diagnostic efficacy it has one limitation in that it cannot provide a quantitative estimate of the confidence with which a site is classified in a specific group (normal or malignant, in the present case). To address this important issue we have investigated the applicability of the recently formulated theory of relevance vector machine (RVM) for development of a probabilistic classification scheme. The RVM based algorithms showed diagnostic performance comparable to SVM. The use of RVM based algorithm would be very helpful in clinical setting where the cost of misclassification is asymmetric, that is one would want to ensure that virtually none of the malignant site is classified as normal even if ensuring this implies that a few of normal sites may get classified as malignant.

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L.2 Development of 60 Watt kinetically–enhanced copper vapor laser

Kinetically–enhanced high power copper vapor lasers (KE-CVLs) are the most recently developed CVL systems. The output power and efficiency increases by factor of 2-3, without any significant change in the design, circuit and total input power of the standard elemental copper vapor lasers. This is accomplished by operating the KE-CVL at higher rep-rate (9- 20 kHz) and using special buffer gas mixture consisting of HCl, hydrogen and neon in highly optimized proportions as per the system requirements [M.J. Withford, D.J.W. Brown, R.P. Mildren, R.J. Carman, G.D. Marshall, J.A. Piper, Progress in Quantum Electronics vol. 28, 2004, p165; *B. Singh, S. R. Daultabad, V. V. Subramanyam, A. Chakraborty,* Proc. National Laser Symposium, Jan. 2005, p115]

The presence of HCl ensures the favorable control of the electron density in the discharge mainly by the process of dissociative-attachment, thereby, enhancing the CVL

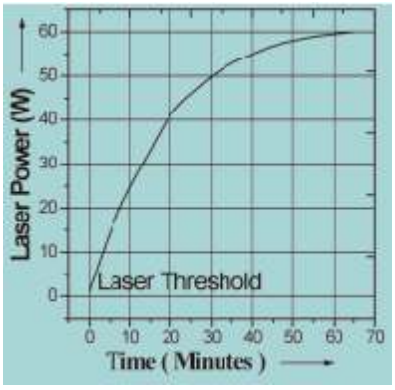

Fig L.2.1 *KE-CVL power buildup with time*