Multimodality imaging in medical diagnostics – challenges and limitations

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Abstract

This presentation is devoted to discussion of challenges and limitations of selected imaging modalities: IR thermograpy, ADT and TSR, electroimpedance tomography in relation to CT and mammography, MRI and USG. Principle of operation is a key factor for different possible applications of a chosen technology. Practically all modalities are of different limitations resulting in achievable accuracy and resolution of the method. Basic properties of each of the most frequently applied in medical practice modalities are compared showing challenges and limitations in selected medical applications. Matching of chosen modalities allows to overcome some limitations and to improve value and quality of combined diagnostics. The role of IR imaging is underlined.

1.   Introduction

Broad overview of most important visualization methods applied in medical diagnostics is given e.g. in [1]. It is well known that each of medical imaging methods is specific but generally may be regarded as functional or structural. Even during last years quality of most of methods have been strongly improved, not all diagnostic information is clearly visible and achievable. One of effective methods to improve quality of diagnostics is multimodality approach, where each modality may underline different diagnostic features. Additionally level of noise may be reduced by matching images of different origin. The aim of this presentation is comparison of basic imaging methods in terms of quality, accuracy, resolution etc and possibility of matching selected methods to provide multimodality diagnostic description of improved quality. IR thermal imaging is here of the highest interest as this is a totally non-invasive and inexpensive modality which may be used not only for fast screening but also as a decisive factor in deep neural network classifiers.

2.   Basic imaging methods in medical diagnostics

Taking into account recent market of imaging instrumentation [1] dominant are ultrasound methods, MRI and CT, including mammography. Unfortunately, each of the methods is of specific disadvantages. In USG geometrical resolution is limited to tissue volume of a few cubic millimetres. MRI is still expensive and investigations are long lasting. CT is regarded as not fully safe. Other features of the methods will be discussed and summarized in the final text.

Here we will focus on thermal imaging methods [2] taking into account static thermography – ST [3], active dynamic thermography – ADT [4,5,6,7] and thermal signal reconstruction method – TSR [8]. All three modalities may be performed using the same instrumentation what makes it's use very attractive. It is already known, that ST, which is showing functional signals, may be regarded as an early detector of metabolic changes, giving significant signs of specific diseases. ADT and TSR are showing the structural info, what is supplementing ST data.

The role of electroimpedance tomography will be also shortly described. This modality is strongly supplementing thermal imaging though the spatial resolution of this method is rather limited,

3.   Multimodality - problems of data processing

Images of different modalities are of different resolution, some are 3-D, may be static or even 4-D, adding the motion component. There are some standards making comparison of images possible, but not for all modalities. So, even DICOM may be regarded as the standard approach, unfortunately IR thermal imaging is not yet adapted to this format. Taking this limitation there are not standard procedures to combine many modalities. Already some commercial solutions allowing automatic matching as e.g. CT-SPECT/CT-PET or multimodality imaging with MR/PET and MR/SPECT are available but are very expensive.

Generally for matching different modalities each choice requires individual solutions. Typical algorithms to be applied are for segmentation and geometry corrections, comparison of series of images, matching 2D and 3D structures, nonlinear corrections etc. In fact very difficult is the problem of finding algorithms for comparison of images taken not at the same moment and using different instrumentation. Additional problems are patient movements during examination.

One of possible solutions is modelling of a tested structure and then comparing measurement data with simulations. Such approach is typical for tomography images but usually simulation problems are ill posed and require advanced iteration calculations what is time consuming and rather expensive.

4. Summary and conclusions

To match any of modalities specific algorithms should be applied, according to the modality and applications. At the moment only selected examples are applied into clinical practice. Multimodality approach is resulting in important improvement of diagnosis. Typically accuracy of a single modality is around 80%, combination of three different modalities may increase the score even to 97-98 %. Unfortunately such improvement is rather expensive, time consuming and hardly accepted by public funding institutions.

The future is promising as cost of diagnostic instrumentation is constantly decreased and new algorithms of data treatment and automatic diagnostic decisions are under development. Especially deep learning neural network algorithms are of a big promise for decision making.

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