IMAGING AND TREATMENT FOR CEREBROVASCULAR DIESEASES

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***Abstract* — Globally, around 15 million people each year suffer a stroke. Only a small fraction of stroke patients who could benefit from thrombolytic treatment reach diagnosis and treatment in time. To increase this low figure we have developed microwave technology aiming to differentiate hemorrhagic from ischemic stroke patients.**

***Index Terms* — Stroke diagnostics, microwave treatment.**

I. Introduction

A. Stroke

The human cost of stroke is horrific. Of the 15 million sufferers 5 million die and another 5 million are permanently disabled. Of the survivors of stroke, 20% have serious remaining dysfunctions but most sufferers are permanently affected to some degree.

The global cost of stroke, including direct and indirect cost is hard to estimate. The corresponding European yearly cost for the around 800 000 stroke patients has been estimated to over 60 billion €. One contributing factor for the high cost is that most stroke patients are under treated which in turn depends on lack of fast and reliable diagnostics.

Thrombolytic treatment of ischemic stroke is today an established procedure but could be disastrous if performed on a patient with a hemorrhagic stroke. As a consequence, in the western world, only 2-5% of ischemic stroke patients who could benefit from thrombolytic treatment reach diagnosis and treatment in time.

In our work we address this problem with the purpose to contribute towards a solution. The aim is a diagnostics systems for stroke for the around 200,000 ambulances around the world and the 15 million yearly stroke patients, that stand to benefit from faster diagnosis and treatment.

II. Results presented

B. Stroke

The measurement prototype that that has been designed and built will be presented. It consists of antennas sending and receiving microwave signals, mounted in a helmet. In order to provide a comfortable fit of the helmet to the head, patch antennas with the surface facing the skull are used. Antennas are distributed uniformly over the surface of the skull to ensure good coverage of the brain. In this system each antenna was consecutively used as a transmitter, with all remaining antennas in receive mode. Each channel was measured over a large band of frequencies, 0.3-3.0 GHz.

A classification algorithm used for stroke diagnostics will be presented. It is uses a labeled set of training data in order to deliver estimates of specific subspaces for each of the two classes. The classification algorithm projects the measurement data vector onto the subspaces and selects the predicted class label based on which of the projections results in the longest vector. The accuracy of the classifier is evaluated on the clinical data using an empirical technique combining the leave-one-out cross validation method, which provides unbiased results, and a boot-strap sampling technique to reduce the variance of the performance estimates. Results from clinical studies using two different brain diagnostic devices based on microwave technology will be presented.

B.Microwave hyperthermia

To this end we have designed, constructed and tested a microwave hyperthermia system with the potential of using a broad frequency range, single frequencies as well as pulses. This is of essence as the optimal frequency for a specific treatment is dependent on the tumour positioning and size. The design is in contrast to existing systems which often work at single frequencies. Another advantage of the broadband approach is that it is more flexible as the environment changes in different exposure situations.

Also, a new focusing technique, based on a time-reversal approach, for microwave hyperthermia has been developed and evaluated. In this method the wave front of the source is propagated through the model of the patient from a virtual antenna placed in the tumour. The simulated radiated field is ”measured” by using the computer models of the surrounding antenna system. The real antenna system is then transmitting the field in a time- reversed order thus focusing the energy deposition.

In a preclinical project which has a a goal to improve the treatment of children with CNS tumors a helmet like strucure has been designed, constructed and tested that uses of focused hyperthermia. The purpose of this work is to contribute to the mitigation of severe late effects for surviving children with CNS tumors by combining radiation with hyperthermia. The heat is to be achieved by focused microwaves which acts as an enhancer of radiation thu allowing to reduce the radiation dose, without decreased tumor control. The hypothesis is that the added microwave heating will allow for reduced radiation with maintained treatment outcome and no added toxicity. Another hypothesis to be investigated is that, for special tumor subtypes, the radiation dose can be lowered by inclusion of chemotherapy and tumor-focused hyperthermia. This is based on the hypothesis that microwaves can cause a local and temporary disruption of the blood-brain barrier resulting in locally enhanced chemotherapy uptake in the treated tumor region. To avoid scarring, the surrounding healthy brain tissue is to be maintained in a mild temperature range of up to 39 degrees Celsius.

III. Conclusion

Our work on microwave based stroke diagnostics sets the stage for pre-hospital stroke diagnosis and treatment. For the society the results will help reducing the large cost of stroke.

We have designed, constructed and tested a microwave hyperthermia system with the potential use on many different solid tumors, including head and neck tumors and children with CNS tumors. The algorithms developed are fast allowing for real time treatment planning and mitigation of undesired focusing of energy, so called hotspots.