Early screening of diabetic foot syndrome by terahertz imaging

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***Abstract*—In this work we present the development of a non-invasive technique for the evaluation of the diabetic foot syndrome using terahertz time domain imaging.**

I. Introduction and Background

DIABETES Mellitus is a disease that afflicts 8,5% of the world population [1]. Diabetes is a chronic disease that occurs when the pancreas does not produce enough insulin or when the body does not effectively use the insulin it produces to regulate the blood glucose levels. High blood glucose, over time, severely damages many organs and systems, especially the nerves and blood vessels [2]. One of the consequences of this disease is the condition known as diabetic foot, a set of neurological and vascular complications that cause loss of sensitivity and ischemia in the extremities which favors the development of ulcers that can lead to amputation of the affected limb. This condition affects 20% of diabetics generating extraordinary costs for patients and public health systems and is the leading cause of non-traumatic amputations [3]. Being one of the most common complications of diabetes, it is essential to make an early diagnosis of diabetic foot and thus give it the necessary treatment. Unfortunately, there are no objective methods for making an adequate diagnosis. In this work we used the ability of terahertz radiation to monitor the skin hydration and correlate the result with the deterioration degree of the diabetic foot.

II. Results

In order to quantify the skin hydration, the complex dielectric function of the dehydrated human skin was measured at terahertz frequencies. Subsequently, using effective medium theory, a model of the dielectric properties of human skin was obtained as a function of the hydration degree. Terahertz images of the foot sole of diabetic and non-diabetic subjects were acquired with a THz-TDS system mounted in reflection mode under a polyethylene window on which the feet were placed. Terahertz images of the foot sole of 33 non-diabetic subjects and 38 diabetic patients were acquired but only 21 of the control group and 12 of the diabetic patients were analyzed. Data were processed and, by fitting a theoretical reflectance model to the experimental reflectance, the water content in the skin was determined in every measurement point and new images were formed with the water content information. A non-diabetic subject and a diabetic patient hydration images are shown in Figure 1. From the hydration images, we can observe a remarkable difference regarding the water content in the foot sole skin, with the skin hydration of the non-diabetic subject being significantly larger than that of the diabetic subject.

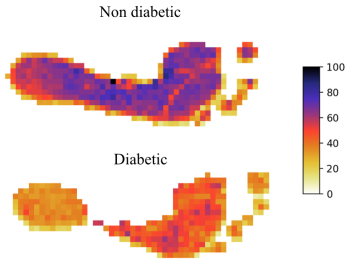

Fig. 1. Hydration images of non-diabetic (top) and diabetic (bottom) subject. The color map represents the skin hydration at the sole of the foot of each volunteer.

III. Conclusion

The feasibility of the proposed technique for the early diagnosis of diabetic foot syndrome is demonstrated [4], [5]. According to the hydration images, we conclude that terahertz imaging is a reliable technique for non-invasively monitoring the hydration degree of the foot sole skin which correlates to the deterioration in the limbs.

References

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