

Ac-Impedance Spectroscopy technique for the detection of dental caries in human teeth

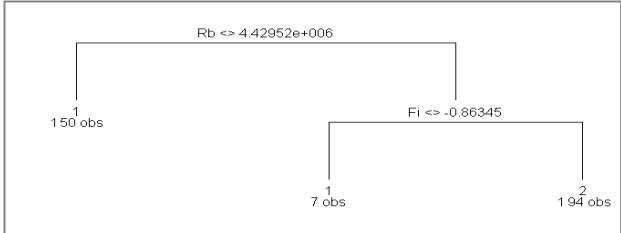
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Aim
 The aim of the study was to apply a theory of classification TREE widely used in data mining algorithms to clinical detection based on the ac-Impedance *in vitro* measurements of teeth at different stages of the caries process. Classification TREE is a rules-derived technique.

- Method**
- The experimental approach was to employ a **pre-production ac-Impedance Spectroscopy (ac-IS) device** with lesion detection software to acquire caries scores on extracted teeth with sound sites and a range of sizes of carious lesions
 - Teeth were equilibrated to conditions similar to the intra-oral environment (humidity 80%, approximating body temp.)
 - 102 teeth were studied by 4 dentists, examining independently and each making repeated assessments.
 - Reference standard evaluations were carried out using a consensus method employing 3 dental examiners assessing surfaces by micro CT supplemented with optimal clinical visual techniques.
 - Classification tree is a rules-derived technique; a TREE is grown by binary recursive partitioning using the response in the specified formula and choosing splits from the variables obtained from ac-Impedance results e.g. Rb – dc conductivity, Z' – real part of the impedance and Fi – the phase angle.

Below we present an example tree. This tree classifies into two groups. Objects for which $Rb > 4.4 \cdot 10^6$ and $Fi > 0.8635$ go to group 2, others go to group 1.

Clinical evaluation based on consensus method of visual examination and m-CT evaluation		Number of sites in each category		
		occlusal	smooth	approximal
Sound	GREEN	20	64	79
Enamel caries / outer 1/2 dentine	YELLOW	85	60	30
Caries in inner 1/2 of dentine	RED	28	14	6
TOTAL		133	138	115



Results

		OCCLUSAL SURFACE		
		SUCCESS RATIO [%]	P [%]	
			MIN	MAX
GREEN	TREE	93	85	98
YELLOW	TREE	86	82	90
RED	TREE	90	83	95

		FREE SMOOTH SURFACE		
		SUCCESS RATIO [%]	P [%]	
			MIN	MAX
GREEN	TREE	94	91	96
YELLOW	TREE	91	84	95
RED	TREE	100	82	100

		APPROXIMAL SURFACE		
		SUCCESS RATIO [%]	P [%]	
			MIN	MAX
GREEN	TREE	91	86	94
YELLOW	TREE	89	81	93
RED	TREE	87	70	95

Conclusion
 It is concluded that the results of diagnostic accuracy are very promising, further validation is appropriate.

Abstract: The aim of the study was to apply a theory of classification TREE widely used in data mining algorithms to clinical detection based on the ac-Impedance *in vitro* measurements of teeth at different stages of the caries process. Classification TREE is a rules-derived technique. A TREE is grown by binary recursive partitioning using the response in the specified formula and choosing splits from the variables obtained from ac-Impedance results e.g. Rb – dc conductivity, Z' – real part of the impedance. The ac-Impedance measurements were carried out using a pre-production IDMoS ac-Impedance Spectroscopy (ac-IS) device on teeth equilibrated to conditions similar to those in the mouth, i.e. humidity of 80% with temperature approximating body temperature. More than 100 teeth were studied by 4 dentists. The clinical reference evaluations of the teeth were carried out on the basis of a consensus by at least 3 dentists and with regard to micro CT images and optimal clinical visual techniques. The ac-Impedance data were analyzed using TREE classification approach and a success ratio defined as: Success ratio = number of samples in agreement with the reference standard divided by the total number of samples used was produced. The performance results were presented for all types of tooth surfaces and in 3 clinical groups: Green (G) – Sound, Yellow (Y) – caries where preventive care is advised and Red (R) – caries where operative care is advised. The following results were obtained for occlusal surfaces: G and Y + R – 93%; smooth surfaces: G and Y + R – 92%; interproximal surfaces: G and Y + R – 94%. It is concluded that the results of diagnostic accuracy are very promising and that further validation is appropriate.