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ACOUSTIC MODELS OF COCHLEAR IMPLANTS

by

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SUMMARY

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Degree: Philosophiae Doctor (Biosystems)

Keywords: Acoustic model, acoustic simulation, current decay, current spread, spread of excitation, simultaneous stimulation, non-linear compression, speech intelligibility, consonant intelligibility, vowel intelligibility, feature transmission.

Acoustic models are useful tools to increase understanding of cochlear implant perception. Two particular issues in modelling cochlear implant perception were considered in the present study, which aimed at improving acoustic models. The first included an electrical layer in the model, while the second manipulated synthesis signal parameters.

Two parts of the study explored the effects of current decay, compression function and simultaneous stimulation, by including the electrical layer. The SPREAD model, which incorporated this layer, yielded the asymptote in speech intelligibility at seven channels observed in CI listeners. It was shown that the intensity of border channels was de-emphasised in relation to more central channels. This was caused by the one-sided effects

of current spread from neighbouring channels for the border channels, as opposed to the two-sided effects for the more central channels. It was theorised that more compressive mapping functions would affect spectral cues and consequently speech intelligibility, but speech intelligibility experiments did not confirm this theory. A simultaneous analogue stimulation (SAS) model, which modelled simultaneous stimulation, yielded intelligibility results that were lower than those of the SPREAD model at 16 channels. The SAS model also appeared to introduce more temporal distortion than the SPREAD model.

A third part of the study endeavoured to improve correspondence of acoustic model results with cochlear implant listener results by using nine different synthesis signals. The best synthesis signal was noise-band based. The widths of these increased linearly from 0.4 mm at the apical to 8 mm at the basal end. Good correspondence between speech recognition outcomes using this synthesis signal with those of CI listeners was found.

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OPSOMMING

AKOESTIESE MODELLE VAN KOGLEÊRE INPLANTINGS

deur

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Sleutelwoorde: Akoestiese model, akoestiese simulasie, stroomverval, stroomverspreiding, spraakherkenning, gelyktydige stimulasie, nie-lineêre samedrukking, spraakherkenning, konsonantherkenning, vokaalherkenning.

Akoestiese modelle word algemeen gebruik om die persepsie van inplantingsgebruikers beter te verstaan. Twee benaderings tot die modellering van kogleêre inplantingsgebruikerpersepsie is voorgestel om akoestiese modelle te verbeter. In die eerste benadering is die generiese model verbeter deur die byvoeging van ’n elektriese laag en in die tweede benadering is sinteseseinparameters gemanipuleer om die ooreenkoms met inplantingsgebruikersuitkomste te verbeter.

Twee dele van die studie het die effek van stroomverspreiding, samedrukkings-funksie en gelyktydige stimulasie ondersoek deur die insluiting van die elektriese laag. Die SPREAD-model het die asimptoot in spraakherkenning by sewe kanale getoon. Die intensiteit van grenskanale is onderbeklemtoon in verhouding met meer sentrale kanale. Dit is veroorsaak

deur die eensydige effekte van stroomverspreiding vir die grenskanale, teenoor die tweesydige effekte wat meer sentrale kanale tipies beïnvloed. Die model het gesuggereer dat meer samedrukkende funksies spektrale inligting sou affekteer, maar spraakherkenningsdata het nie hierdie teorie bevestig nie.

Die gelyktydige- analoogstimulasiemodel, wat gelyktydige stimulasie gemodelleer het, het soortgelyke tendense getoon, maar met meer temporale effekte as die SPREAD-model. Die gelyktydige- analoogstimulasiemodel-model se resultate was ook swakker by 16 kanale as die SPREAD-modelresultate.

Die derde deel van die studie het gepoog om beter ooreenkoms tussen modeluitkomste en inplantingsgebruikeruitkomste te verkry deur nege verskillende sinteseseine te gebruik. Die beste sintesesein was die ruisband met veranderende wydte; hierdie wydte het verbreed vanaf 0.4 mm by die apeks tot by 8 mm by die basis. ‘n Goeie ooreenkoms is verkry tussen modeluitkomste en inplantingsgebruikeruitkomste deur hierdie sintesesein te gebruik.

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Trudie Strydom

LIST OF ABBREVIATIONS

ACE	Advanced combination encoder
CI	Cochlear implant
CIS	Continuous interleaved sampling
EDR	Electrical dynamic range
IDR	Input dynamic range
PPS	Paired pulsatile stimulation
pps	Pulse per second
ppspch	Pulse per second per channel
PSD	Power spectral density
SAS	Simultaneous analogue stimulation
SD	Standard deviation
SNR	Signal-to-noise ratio
SPEAK	Spectral peak
TMTF	Temporal modulation transfer function
QPS	Quadrupolar pulsatile stimulation

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