Introduction

Real-ear measurement (REM) is widely considered best practice for hearing aid verification. REM uses a probe tube connected to a probe microphone to record amplified signals in the ear canal. The interaction of incident and reflected sound results in standing waves that cause the SPL to vary along the ear canal [1]. For accurate REM, the probe tube should be placed within 5-6 mm of the tympanic membrane (TM) [2], but not so close that it may contact the eardrum and cause discomfort.

Clinicians currently must rely on visual inspection or complex acoustic techniques to position the probe tube which may be a barrier to REM adoption.

Data generation and modelling

Cancellation due to ¼ wavelength reflection.
Cancellation due to ¼ wavelength reflection.
Noise from handling the probe tube.

5-fold cross validation is used to assess model performance.

All test predictions for each model in the 5-fold cross validation (N = 77056).
Percentiles are calculated in 2.5mm wide bins.
Predictions at the extremes are skewed, partly due to initial adaptation when probe tube is already inserted at start of sequence.

5-fold cross validation is manually labelled by drawing a red line through the estimated path of the probe tube.
A plot digitizer converts the red line to tabular data for RNN training.

Recurrent Neural Network training and model selection

Table 1: 5-fold cross validation results of best model.

Examples of model output (Fold 4)

Clinical Interface

Using recurrent neural network modeling techniques to assist with probe tube placement is promising. The model accurately predicts the position of the probe-tube. Early investigation suggests the model is robust to extraneous noise and does not require modification of typical clinical methods of handling and inserting probe tubes.

Future work will evaluate REM differences for the guided system approach versus visually assisted methods with experienced clinicians, comparing REURs and probe tube insertion depths.

Future investigations could consider extending the model to populations with varied ear canal properties relative to the current adult sample (e.g., infants, children, people with outer/middle ear dysfunction).

References