ACOUSTIC SOURCE LOCALISATION

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Contents

Abstract

Many New Zealand native bird species are under threat, and as such conservationists are interested in obtaining accurate estimates of population density in order to closely monitor the changes in abundance of these species over time. One method of estimating the presence and abundance of birdlife in an area is using acoustic recorders; currently, omnidirectional microphones are used, which provide no estimate of the direction of arrival of the call. An estimate of the direction from which each sound came from would help to discern one individual calling multiple times, from multiple birds calling in succession – thus providing more accurate information to models of population density. The estimation of this direction-of-arrival (or DOA) for each source is known as *acoustic source localisation*, and is the subject of this work.

This thesis contains a discussion and application of two families of algorithm for acoustic source localisation: those based on the Generalised Cross-Correlation (GCC) algorithm, which applies weightings to the calculation of the cross-correlation of two signals; and those based on the Multiple Signal Classification (MUSIC) algorithm, which provides an estimate of source direction based on subspaces generated by the covariance matrix of the data. As the MUSIC algorithm was originally described for narrowband signals – an assumption not applicable to birdsong – we discuss several adaptations of MUSIC to the broadband scenario; one such adaptation requiring the use of polynomial matrices, which are described herein.

An experiment was conducted during this work to determine the effect that the distance between the microphones in a microphone array has on the ability of that array to localise various acoustic signals, including the New Zealand native North Island Brown Kiwi, *Apteryx mantelli*. It was found that both GCC and MUSIC benefit from larger inter-array spacings, and that a variant of the MUSIC algorithm known as autofocusing MUSIC (or AF-MUSIC) provided the most precise DOA estimates.

Though native birdlife was the motivator for the research, none of the methods described within this thesis are necessarily bound only to work on recordings of bird-song; indeed, any multichannel audio which satisfies the necessary assumptions for each algorithm would be suitable.

As well as a description of the algorithms, an implementation of GCC, MUSIC, and AF-MUSIC was produced in the Python 3 programming language, and is available at `https://github.com/alexW335/Locator`.

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