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School of Engineering, Discipline of Mechanical Engineering, pp. 1– 87 Pro of of Concept Design of an Acoustic Beamforming Microphone Array for the Early Detection of Defects Final Year Project Report - MECH4841 Part B June 2020 Samuel Willis 1 1 Student of Mechanical Engineering, The University of Newcastle, Callaghan, NSW 2308, AUSTRALIA Student Number: 3256767 E-mail: s.willis @uon.edu.au The University of Newcastle, AUSTRALIA MECH4841 Part B School of Engineering, Discipline of Mechanical Engineering Dot Point Summary ˆ Developed a simulation package for beamforming array algorithms and geometries. ˆ Designed and built a working beamforming array. ˆ Implemented a time-domain and frequency-domain algorithm for beamforming. ˆ Demonstrated the acoustic array differentiating between two different simultaneous sound sources using the MUSIC algorithm. ˆ Tested the acoustic array on in-service turbines for the purpose of locating unknown sound sources. FYP Report - Acoustic Beamforming Array Final Year Project Part B - COVID19 Impact Statement The University of Newcastle understands that the Covid 19 Pandemic may have negatively affected students in different ways during 2020. In the spirit of fairness, the Discipline of Mechanical, Mechatronic and Aerospace systems Engineering invite students to disclose any issues that may have affected the progress and outcome of their final year program. These issues will be taken under considerations when assessing your project. Issues may include, but are not limited to: financial/employment and accommodation issues. Illness and or death of a loved one, impact of caring for loved ones and dependants (including home schooling.) Difficulty accessing laboratory space, equipment and or specialist computer software. Other. My final year project was impacted by Covid 19 due to the lockdowns and close of business across the local-area, I was unable to test my array to its full extent due to equipment being in lock down at a local power station and was unable to easily get onto site for testing due to the lock downs at local power stations as well. School of Engineering, Discipline of Mechanical Engineering Abstract Locating defects and fault on plant can be difficult when a problem cannot be confidently diagnosed or located, now with the high availability of MEMS Microphones due to the ever-increasing demand of smartphones, acoustic arrays consisting of large quantities of MEMS microphones have been made much more achievable without huge capital outlays. An array consisting of a large number of MEMS Microphones allows for the beamforming of incoming signals and the locating of unknown sound sources. The core aims of this project were to design and build an acoustic array consisting of up to 48 microphones that would be able to locate individual unknown sound sources from within a noisy environment for the purpose of locating defects in machinery by employing two different algorithms, the delay-and-sum and MUltiple SIgnal Classification (MUSIC). Once satisfied to be working the aim was to evaluate the performance of the acoustic array in detecting defects on in-service machinery in an industrial environment. The final array consisted of 24 microphones and proved to differentiate and locate mul- tiple sound sources in a noisy environment using the MUSIC algorithm with ease, this algorithm allowed for the ability to target either a specific frequency or set of frequencies to spatially search for, easily differentiating sound sources. In the limited on-site testing at a local power station, the array was unable to determine the location of any noises present on an in-service turbine due to the harsh sound environment, though with further on-site testing and software refinement this array should be able to locate machine defects as it has shown in the lab environment. FYP Report - Acoustic Beamforming Array Contents 1. Introduction 2. Literature Review 2.1. Acoustic Beamforming . . . . . 2.2. Digital Signal Processing . . . . . 2.2.1. Fourier Transform . . . . 2 .2.2. Delay-and-Sum Beamformer . . . . . 2.2.3. Frequency-Domain Beamformer . . . . . 2.2.4. MUSIC Algorithm . . . . . 2.3. Condition Monitoring . . . . . 3. Aims and Objectives 3.1. Problem . . . . . 3.2. Use of Microphone Arrays for Condition Monitoring . . . . . 3.3. Project Aim . . . . . 4. Software Research and Development 4.1. Delay-and-Sum