#### Robust Audio Zoom for Surveillance Systems: A Beamforming Approach with Reduced Microphone Array

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### Introduction

- AUDIO ZOOMING ENABLES FOCUSING ON SPECIFIC SOUNDS IN AN AUDITORY SCENE, ANALOGOUS TO A CAMERA'S VISUAL ZOOM. POTENTIAL APPLICATIONS INCLUDE SURVEILLANCE AND BROADCASTING.
- REPLICATING THE HUMAN BRAIN'S NOISE FILTERING CAPABILITIES IN TECHNOLOGY, ALSO KNOWN AS "THE COCKTAIL PARTY PROBLEM," POSES A SIGNIFICANT CHALLENGE AND CAN IMPEDE ACCURATE SOUND EXTRACTION.

## Related Work

 KEY STUDIES ON THE COCKTAIL PARTY PROBLEM AND AUDIO ZOOMING INCLUDE WORKS BY CHERRY [1], VAN WATERSCHOOT ET AL. [2], THIERGART, KOWALCZYK, AND HABETS [3] AND FAHIM ET AL. [4]

TO DATE, NO AUDIO AND VIDEO ZOOM ALIGNMENT HAS BEEN DEVELOPED FOR A SURVEILLANCE SYSTEM.

[1] E. C. CHERRY, "SOME EXPERIMENTS ON THE RECOGNITION OF SPEECH, WITH ONE AND WITH TWO EARS," THE JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA, VOL. 25, NO. 5, PP. 975-979, 1953, DOI: 10.1121/1.1907229.

[2] T. VAN WATERSCHOOT, W. JOOS TIRRY, AND M. MOONEN, "ACOUSTIC ZOOMING BY MULTIMICROPHONE SOUND SCENE MANIPULATION," AUDIO ENGINEERING SOCIETY, VOL. 61, 7/8, 2013.

[3] O. THIERGART, K. KOWALCZYK, AND E. A. P. HABETS, "AN ACOUSTICAL ZOOM BASED ON INFORMED SPATIAL FILTERING," 2014 2014: IEEE, DOI: 10.1109/IWAENC.2014.6953348. [ONLINE]. AVAILABLE: <u>HTTPS://DX.DOI.ORG/10.1109/IWAENC.2014.6953348</u>

[4] A. FAHIM, P. N. SAMARASINGHE, AND T. D. ABHAYAPALA, "SOUND FIELD SEPARATION IN A MIXED ACOUSTIC ENVIRONMENT USING A SPARSE ARRAY OF HIGHER ORDER SPHERICAL MICROPHONES," IN 2017 HANDS-FREE SPEECH COMMUNICATIONS AND MICROPHONE ARRAYS (HSCMA), 1-3 MARCH 2017 2017, PP. 151-155, DOI: 10.1109/HSCMA.2017.7895580.



# Proposed Research

- OUR EXPERIMENTAL SETUP INVOLVED PARTITIONING A STUDIO SPACE INTO A 3X3 GRID WITH NINE SPEAKERS AND A SQUARE MICROPHONE ARRAY (16 OMNIDIRECTIONAL MICROPHONES) POSITIONED IN THE CENTRE.
- TO COMPENSATE FOR MICROPHONE FAILURES, WE EMPLOYED THE DELAY AND SUM BEAMFORMING TECHNIQUE WITH A REDUCED ARRAY OF 13 OPERATIONAL MICROPHONES FOR ACCURATE AUDIO SIGNAL ENHANCEMENT.



2 3 4

Mic 7

Mic 11

3

Mic 15

4

2

1 2 3 4 5

2

2

2

2 3

3

Mic 16

Mic 12

3

Mic 8

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3

3 4

Mic 14

Mic 10

1 2

Mic 6

2 3 4

2 3 4

1 2

Mic 9

3 4

Mic 13

2 3

Mic 5



#### Data Processing and Analysis

DATA PROCESSING AND ANALYSIS WERE CONDUCTED USING A MATLAB SCRIPT, ENABLING 3D VISUALISATION OF THE EXPERIMENTAL SETUP AND CALCULATING MICROPHONE-SPEAKER DISTANCES, TIME DELAYS, AND BEAMFORMING FOR THE SELECTED GRID.







#### Beamforming with Reduced Microphone Array

- MICROPHONE FAILURES WERE SIMULATED BY DISABLING THREE MICROPHONES IN THE ARRAY, AND THE BEAMFORMING ALGORITHM'S PERFORMANCE WAS EVALUATED.
- THE RESULTING COMPARISON AND CROSS-CORRELATION ANALYSIS PROVIDE INSIGHTS INTO THE ALGORITHM'S ROBUSTNESS IN THE PRESENCE OF FAILURES.

**Polar Patterns of Microphone Array** 



# Polar Plot Analysis

THESE POLAR PLOTS REPRESENT THE BEAMFORMING PATTERN DIRECTED TOWARDS THE CHOSEN GRID AND NOT THE COMPLETE DIRECTIVITY PATTERN OF THE PLANAR MICROPHONE ARRAY WITH OMNIDIRECTIONAL MICROPHONES.





#### Beamforming Results and Analysis

BOTH THE FULL 16-MICROPHONE ARRAY AND THE REDUCED 13-MICROPHONE ARRAY EXHIBITED HIGH DIRECTIVITY INDEX (DI) VALUES, INDICATING STRONG DIRECTIVITY AND EFFECTIVE BEAMFORMING DESPITE MICROPHONE FAILURES.

THE BEAMFORMED SIGNALS SHOWED ONLY MINOR VARIATIONS, DEMONSTRATING THE ALGORITHM'S RESILIENCE TO NON-OPERATIONAL MICROPHONES WHILE MAINTAINING SATISFACTORY PERFORMANCE.

## Conclusion and Future Research

- THE STUDY DEMONSTRATES THE ROBUSTNESS OF THE DELAY AND SUM BEAMFORMING ALGORITHM AGAINST MICROPHONE FAILURES AND ITS SATISFACTORY PERFORMANCE WITH A REDUCED MICROPHONE ARRAY.
- THE RESEARCH HAS POTENTIAL APPLICATIONS IN FORENSIC EVIDENCE COLLECTION AND BROADCASTING, LEVERAGING THE ALIGNMENT OF AUDIO AND VIDEO ZOOMING.
- FUTURE RESEARCH SHOULD FOCUS ON ENHANCING BEAMFORMING ALGORITHMS, EXPLORING MICROPHONE PLACEMENT, AND INTEGRATING SILMULTAANIOUS AUDIO AND VIDEO ZOOMING FOR MORE COMPREHENSIVE SURVEILLANCE APPLICATIONS.

### Q&A and Contact Information

HAPPY TO ANSWER QUESTIONS.

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