

## **Audio Research**



# Investigating Hypersonic Sound for Outdoor AR Applications

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# Outline



- Hypersonic Sound Background
- Pilot Experiments
  - Projection Field dB Mapping
  - Methodology Development
- Main Experiment
  - Experimental Setup
  - Data Gathering
  - Data Analysis
  - Conclusions







- Generates a beam of (2 frequency) ultrasonic energy
- Heterodyne -> audible within the beam
- Creates a "virtual sound source" by reflecting the beam off of a surface





# **HSS** Projector







# Hypersonic Sound



- Localization Studies
  - Beam dispersion
  - comparisons
    with
    conventional
    speaker

								D	egrees		
			880	) Hz T	est			V	ertical		
										dB	
P	A SPEAKE	R			HS	SS UL	TRA	SOUN	ID		
68	72	77	78		69	66	61	58	31	79,78	
68	66	70	75		73	69	64	58	22	77,76	
75	76	77	74		77	73	67	57	11	75,74	
76	77	80	78		79	75	66	60	0	73,72	
71	72	67	72		74	73	66	61	11	71,70	
77	79	77	79		71	70	64	60	22	69,68	
71	71	73	74		68	67	65	62	31	67,66	
75	76	77	77		64	63	59	58	40	65,64	
					HSS					63,62	
										61,60	
-31	-22	-11	0		0	11	22	31		59,58,57	·
			Degr	ees la	ateral						





HOUSE

- Pilot Study
  Key issues:
- Background noise (how loud to interfere?)
- Data collection time (how to develop a parallel process?)
- Different projection conditions







- Pilot outcomes:
- 56dB or less ambient, OK
- BOTH HSS units died
- Quest for replacements took 9 months
- Adobe Illustrator methodology - perfected







Main Study



- PREPARATION
  - Identify usable site (UCF Research Park)
  - Pre-measure & mark (Nails in tarmac)
  - Recruit Students (Digital Media, \$10 ea.)
    - 15 students, 3\*5 groups, one per emitter site
    - mixed male/female



# Site Map







# Site Photo (Location 6)







Apparatus & Setup



- Compass Rose (5 units)
  - Aligned by hand compass To Magnetic North
  - Three PHASES of test:
  - Emitter Right (location S1)
  - Emitter Center (location G)
  - Emitter Left (location J)







## Experiment in Progress

Each PHASE Had:

- 5 Subjects
- 5 Handlers
- 1 Operator









- Procedure:
- Projector randomly points to one of 5 targets on wall
- Subjects close eyes, walk around compass, point to perceived sound location.



- Handlers record angle of perceived sound and confidence level (1 5)
- Repeat for all 5 target locations.
- Rotate subjects. Each subject visits 5 stations x 5 sound-locs.







				Confi		Projector
Pass	Station	Step	Direc.	-dence	Subj.	Location
1	2	А	5	5	15	1
1	2	В	50	5	15	1
1	2	С	65	5	15	1
1	2	D	45	5	15	1
1	2	Е	30	3	15	1
2	2	А	35	3	15	1
2	2	В	340	2	15	1
2	2	С	5	4	15	1





Etc.

Pass 1	Location:	A -> T B -> R C -> U	
		D -> S E -> Q	
Pass 2	Location:	A -> Q B -> S	
		C -> U	
		D -> R E _> T	
		ONR Review January 2005	



### Data Map Preparation









- Vectors' angle is plotted
- Length == confidence
- Color == which subject



	A	6	с	D
S1		64.8ñ	54.2ít	
G	71.0ft	46.6ft		
J	48.3ft	95.3ft		
1		87.0ft	51.6ft	
2		49.7ft	91.6ft	
3	88.7ft	65.7ft		
4	73.2ft	93.8ft		
5	63.0ft			84.7ft





- Vectors' angle is plotted
- Length == confidence
- Color ==
  which subject

Example:

Target Q,



60

	A	6	с	D
51		64.8ñ	54.2ft	
3	71.0ft	46.6ft		
	48.3ft	95.3ft		
1		87.0ft	51.6ft	
2		49.7ft	91.6ft	
3	88.7ft	65.7ft		
4	73.2ft	98.8ft		
5	63.0ft			84.7ft

Source G \_\_\_\_\_\_ Systematic error from this location \_\_\_\_\_\_ due to source position.



### Data Map Preparation





























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## Discussion





