VOICE-CONTROLLED CHESS GAME ON FGPA USING DYNAMIC TIME WARPING

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OVERVIEW

- Multiplayer digital chess game
- Players deliver voice commands to game
- Driven by voice recognition hardware and move-checking logic
DIVISION OF LABOR

- The project is divided into two parts:
  - 1. Voice Recognition Engine (Varun)
     - Compares voice commands to saved samples
     - Uses Dynamic Time Warping (DTW) Algorithm to compare
     - Returns command corresponding to closest match
  - 2. Chess Game Engine (Michael)
     - Takes input from the Voice Recognition Engine or keyboard
     - Checks the validity of moves
     - Displays the chessboard and chess pieces on an XVGA display
HIGH LEVEL BLOCK DIAGRAM

Voice-Command

Voice Recognition Engine

Command

Chess Game Engine

VGA-Display

Keyboard Command
VOICE RECOGNITION ENGINE

AC97

from_AC97

8

Downsample 48kHz to 4 kHz

filtered

8

FIR31 +

2K x 8

Buffer Memory

AC97 Commands

Signals (L to R)

sound_in 8b

WE 1b

Addr 11b

sound_out 8b

Program

Category

Word

8

Virtual

Address

temp

WE

1 3

1

3

1 0

8

3

3

Dist

dist

en

vr_to_chess

vr_new_command

To all 8, select with mux

Total Memory

104K x 8 = 832 Kbits

DTW Engine

dtw

DTW System Controller

2K x 8

possible_match

dist

category

addr

en

temp

WE

1 3

1

3

category

3

category

3

word

3

program
DYNAMIC TIME WARPING (DTW) ENGINE

Total Memory
104 Kbits
DYNAMIC TIME WARPING
EXPLAINED

- Compares input sample of A (N samples) to template B (M samples) and returns a least cost “distance” between the two
  - Forms M x N matrix D, \( D_{ij} = (A_i - B_j)^2 \)
  - Forms second M x N matrix Gamma:
    - Row 0 and Column 0 of Gamma set to Infinity; \( \Gamma_{0,0} = 0 \)
    - For all other elements \( \Gamma_{ij} = D_{ij} + \min( \Gamma_{i-1,j}, \Gamma_{i,j-1}, \Gamma_{i-1,j-1} ) \)

- Return \( \Gamma_{N,M} \) as the distance measure between A and B

- Optimizations
  - Our maximum N and M are 2K for a memory requirement of 16K x 16K for both Gamma AND D
  - But...
  - We can certainly calculate D values on the fly with a pipelined circuit
  - And...
  - The algorithm only ever calls on data from two complete rows, so we only need to store 2 in a rolling buffer style memory, cutting memory down to 16K x 2
CHESS & GRAPHICS ENGINES

vr_to_chess

kb_to_chess

vr_kb_switch

vr_new_command

kb_new_command

vr_kb_switch

to_chess

move_board_set

move_board_we

move_square

move_piece

new_command

KEYBOARD ENCODER

[24x8 FIFO]

ps2_kbd

(Term, Chuang)

ASCII

8

ascii

ascii_ready

MOVE CHECKER

check_move

check_done

check_result

check_board_set

check_square

check_piece

24x8 cstring

STRING DISP &

fotram

(Term, Chuang)

VIDEO PRIORIT

ENCODER

VIDEO

PIECE GRAPHICS

ROM

12x64x64

CHESS PIECES

CHESSBOARD

cstringdisp &

fontram

(Term, Chuang)

hcount,

vcount (from xvg)

pixel

Old Board

64 x 8

New Board

64 x 8

Pieces

32x5

CHESS & GRAPHICS ENGINES

Old Board

64 x 8

New Board

64 x 8

Pieces

32x5
CHESS ENGINE FSM

WAITING FOR PLAYER 1

CHECK MOVE

CHECK MOVE

WAITING FOR PLAYER 2

new command

invalid move

valid move

valid move

invalid move

new_command
MOVE CHECKING

- Checks that proposed move is characteristic of piece’s style of movement (e.g. knight from G1 to F3)
- Checks whether castling is still permissible
- Checks whether pawn can still perform a two-square advance
EXTENSIONS

- Chess Module
  - Check and Check-Mate Checking
  - Non-Queen Promotion
  - En Passant Captures

- Voice Recognition Module
  - Multi-Voice Recognition
  - Support Promotion and En Passant Captures
## TIMELINE & MILESTONES

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<th>Owner</th>
<th>Date</th>
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<td>Valid Sample Detection</td>
<td>Varun</td>
<td>19-Nov</td>
</tr>
<tr>
<td>Complete Keyboard Encoder</td>
<td>Michael</td>
<td>24-Nov</td>
</tr>
<tr>
<td>Complete Keyboard Entry -&gt; Screen Capability</td>
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<tr>
<td>Time Warping Demonstrated</td>
<td>Varun</td>
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<tr>
<td>Complete Move Checker</td>
<td>Michael</td>
<td>26-Nov</td>
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<td>Complete Chess Engine and Board Representations</td>
<td>Michael</td>
<td>3-Dec</td>
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<tr>
<td>Complete Chess Graphics Capability</td>
<td>Michael</td>
<td>3-Dec</td>
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<tr>
<td>Memories Instantiated</td>
<td>Varun</td>
<td>3-Dec</td>
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<tr>
<td>One DTW Engine Fully Functional</td>
<td>Varun</td>
<td>3-Dec</td>
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<td>Whole DTW System Functional</td>
<td>Varun</td>
<td>5-Dec</td>
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<td>Integrate System</td>
<td>M &amp; V</td>
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Questions?