

A FPGA Accelerated AI for Connect-5

ECE532 Digital Systems Design

David Biancolin

Mohamed Kayed

Ritchie Zhao

Goal

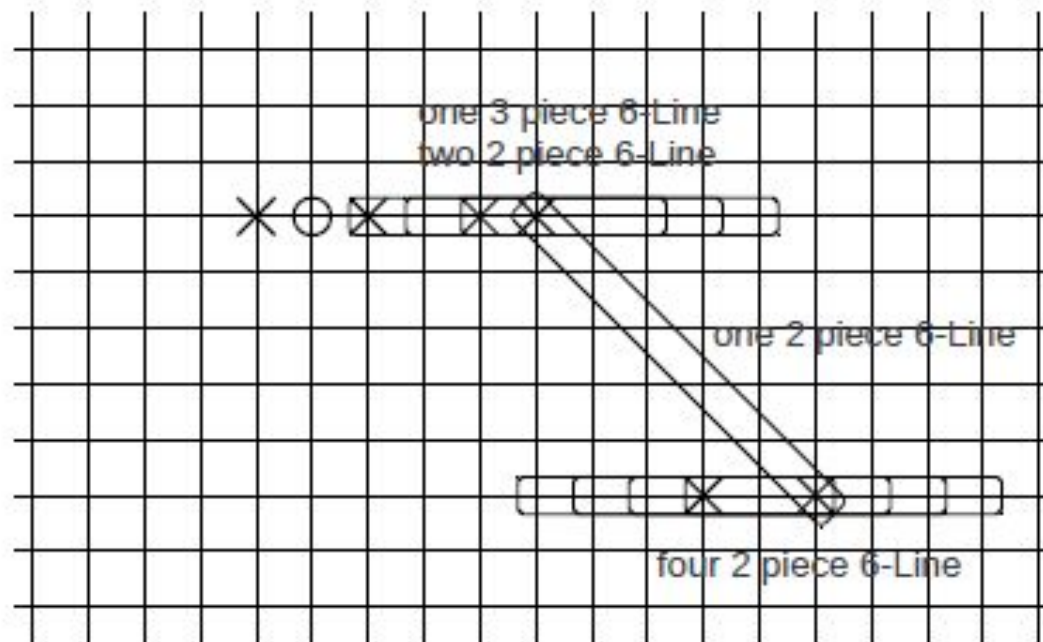
- Build an AI for connect-5 (Gomoku) in FPGA hardware and leverage Vivado's High Level Synthesis functions
- The AI should run faster than its software counterpart running on a top of the line general purpose PC
- The AI should be competitive with software AIs on Gomocup

Literature Review

- Began by looking at papers from ICFPT design competition
 - 2013: Blokus
 - 2012: Connect-6 Variant
- Most papers use a board evaluation function and brute force every possible
- Sometimes search forward n-ply using a minimax tree, but cannot examine every move

Board Evaluation

- Board Evaluation Function sweeps a 5-square mask across board. Adds a number based on the pattern inside the window to board score.

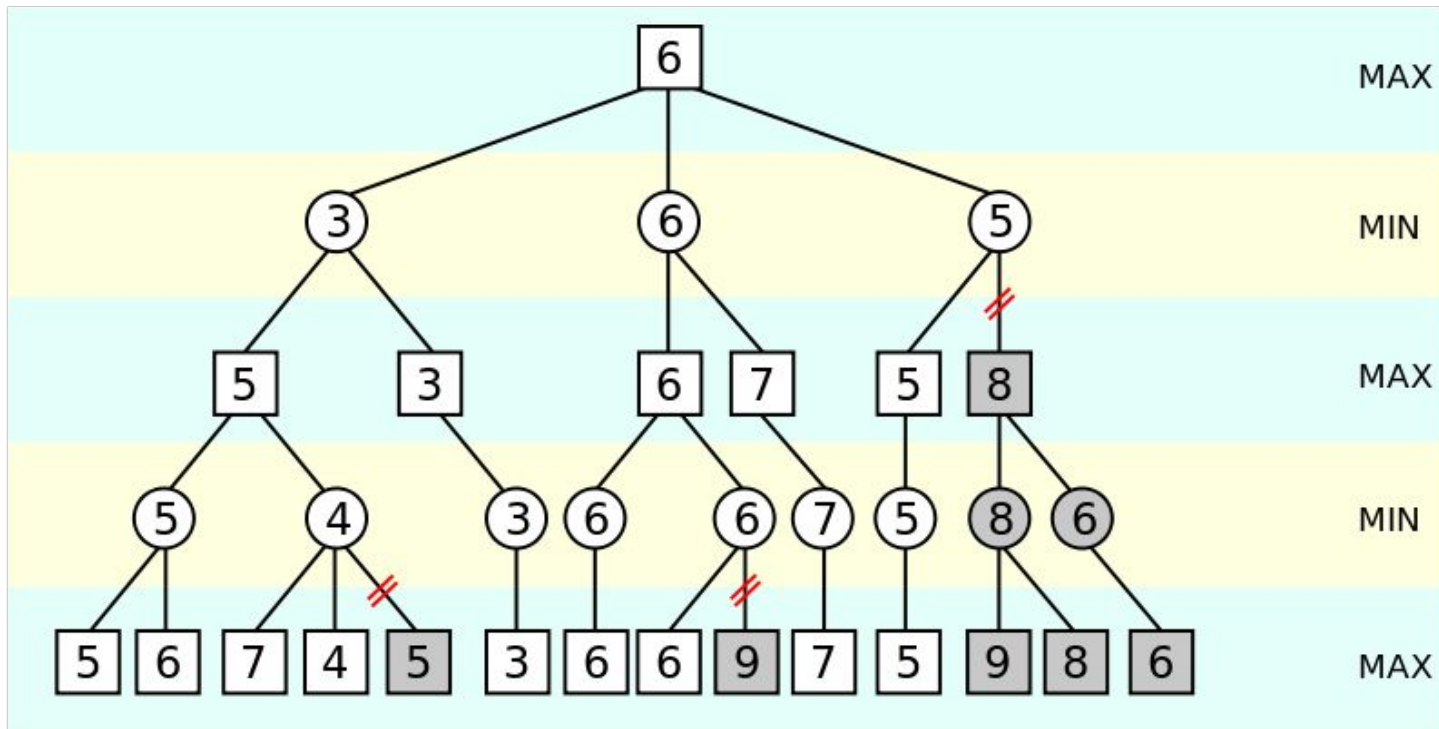


Board Evaluation (Cont.)

- If the board is represented with a bit-board, the BEF is just bit-manipulation, and can be done in hardware in parallel
- Other mask functions can be used to determine relevant squares (squares which extend or block a pattern) and trim away irrelevant positions

Search Tree

- Minimax Search Tree + Alpha-Beta Pruning



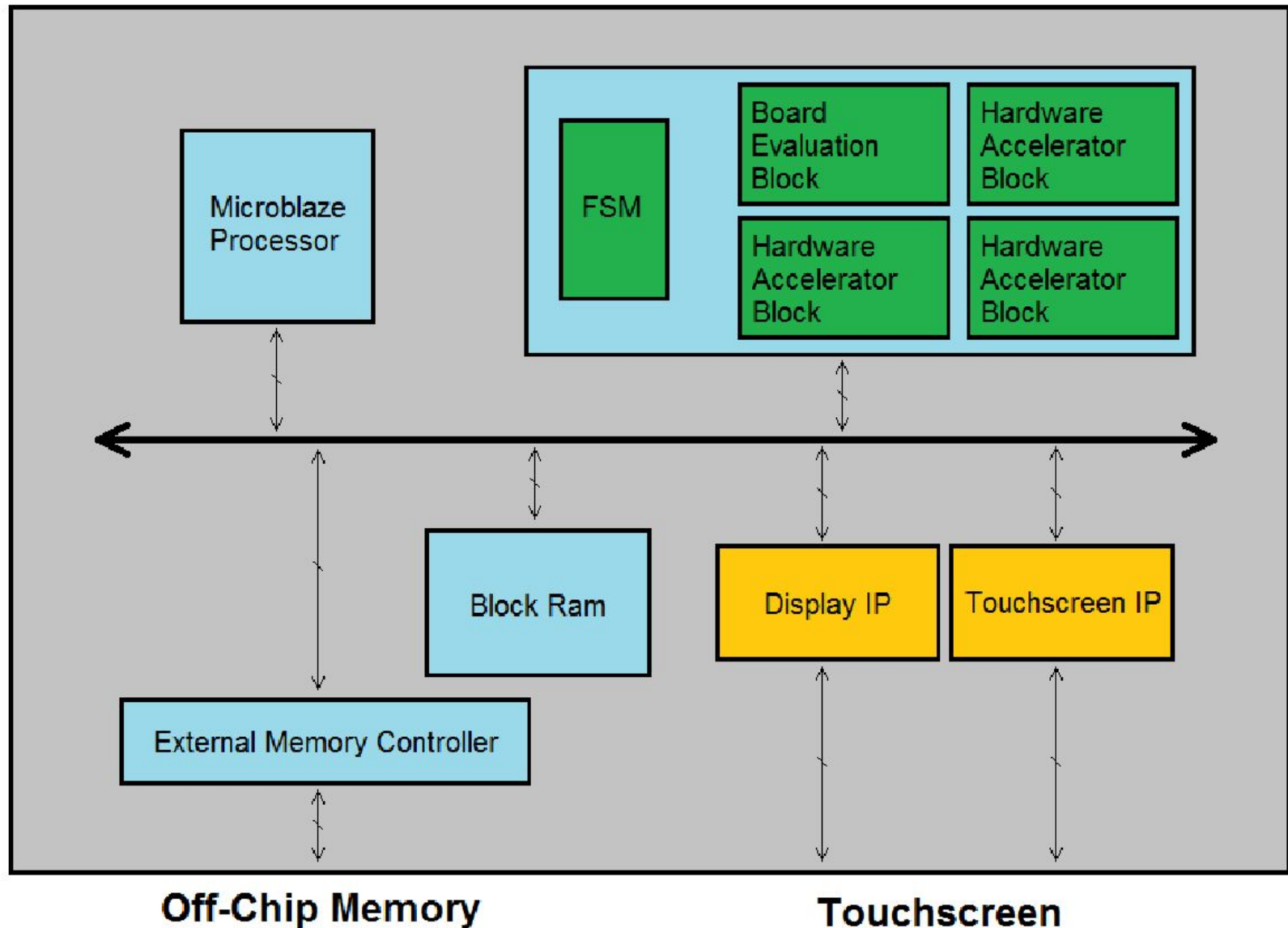
Search Tree (Cont.)

- To avoid dynamic memory allocation, we will specify how many moves per level and the maximum height of the tree
- The traversal algorithm will also be sequential and not recursive
- Possible to parallelize the traversal in hardware

Hardware Acceleration

- Instead of checking the squares in a mask sequentially, a hardware module can do all the checks in one cycle
- CPU writes data to predefined locations, the block reads the data, performs the calculations, and write back result
- FSM used to track program state and alert CPU when hardware modules are done

Block Diagram



Plan of Action

- Phase 1:
 - Write the AI in C
 - Build the game GUI using the touchscreen IP
- Phase 2:
 - Run the AI purely on Microblaze, get the system to a point where one can play a game
- Phase 3:
 - Accelerate the AI by choosing certain functions to convert to hardware