A FPGA Accelerated AI for Connect-5

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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.
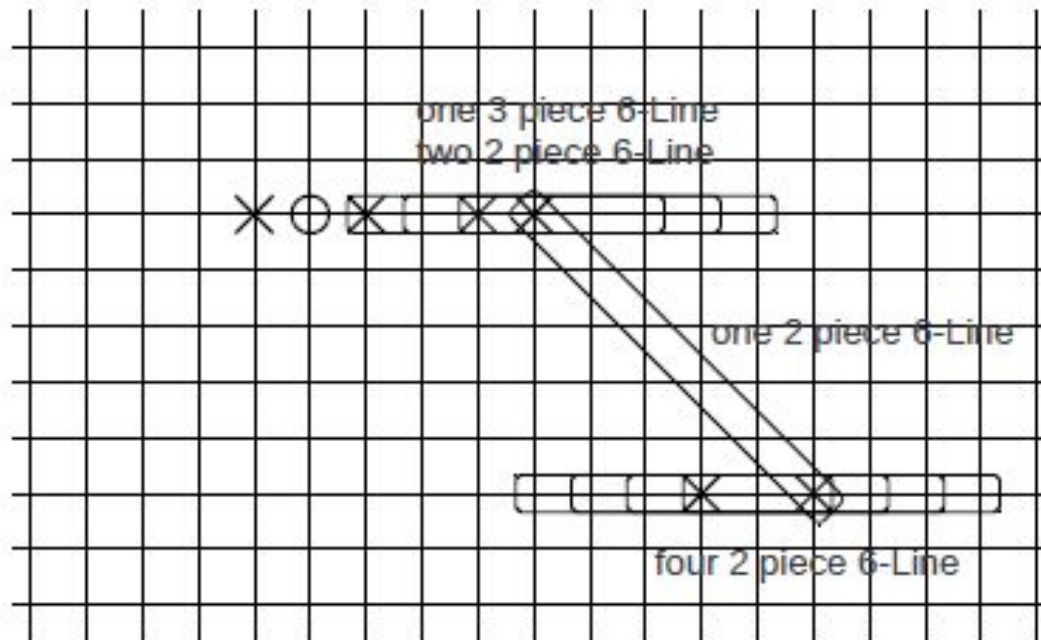
Board Evaluation (Cont.)

- 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
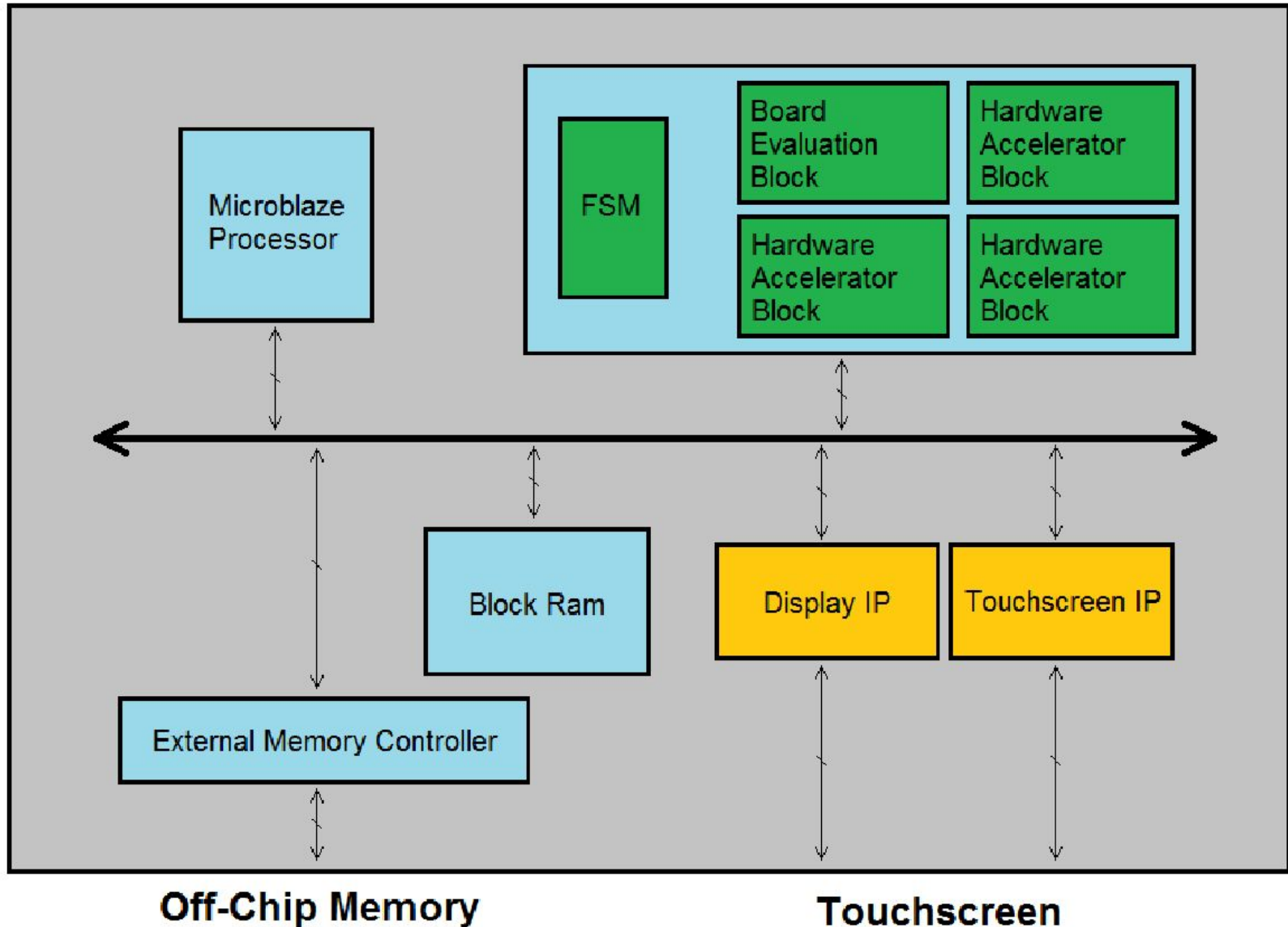
Plan of Action

- 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