

# ECE4893A/CS4803MPG: MULTICORE AND GPU PROGRAMMING FOR VIDEO GAMES

Lecture 2: History of Video Gaming Hardware: The 2-D Era

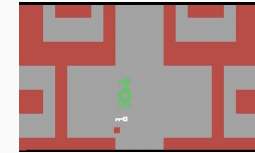


Prof. Aaron Lanterman  
School of Electrical and Computer Engineering  
Georgia Institute of Technology

Georgia Institute of Technology

## Atari 2600 VCS (1977)

- $\approx 1$  MHz MOS 6507
  - low-cost version of 6502
- 128 bytes RAM
- First ROM cartridges 2K, later 4K
- Discontinued 1992
- Retro releases now on the market!



Adventure



Solaris

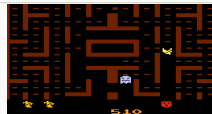


Georgia Institute of Technology

Pics & info from Wikipedia

## Atari 2600 Hardware Tricks

- Could put RAM on the cartridge
  - “Atari Super Chip”
  - 128 more bytes!
  - Jr. Pac-Man
- “Bank switching” to put more ROM on cartridge
  - Only 4K immediately addressable - game still has to operate within individual 4K chunks at a time
  - Mr. Do!’s Castle (8K), Road Runner (16K, 1989)
  - Fatal Run (only 32K game released, 1990)



Georgia Institute of Technology

Info & pics from AtariAge

## Atari 2600 Hardware Tricks

- “M Network” games
  - Atari 2600 games produced by Mattel
  - Controversial decision within Mattel
  - Done by same group that designed the Intellivision: APH Technology Consulting
- Super Charger added 2K RAM
  - Originally planned as a hardware add-ons
  - Public didn’t seem to like add-ons, so built in separately into each cartridge
  - BurgerTime: Cleverness beats hardware!



Info & pic from [www.intellivisionlives.com/bluesky/games/credits/atari1.shtml](http://www.intellivisionlives.com/bluesky/games/credits/atari1.shtml)  
[www.intellivisionlives.com/bluesky/games/credits/atari2.shtml](http://www.intellivisionlives.com/bluesky/games/credits/atari2.shtml)

Georgia Institute of Technology

## Atari 2600 - The Chess Story (1)

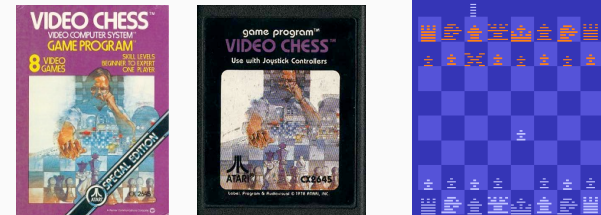
- "Atari never intended to create a Chess game for the Atari 2600"
- "the original VCS box had a chess piece on it, and Atari was ultimately sued by someone in Florida due to the lack of an actual chess game"
- "Some time later Atari's engineers began working on a version of Chess for the 2600"

Quotes from AtariAge page on Video Chess



## Atari 2600 - The Chess Story (2)

- "Although Video Chess ended up shipping as a 4K game, earlier versions of the game were larger...This prompted Atari to invent bank-switching ROMs which would be used in later titles that needed more than 4K..."



Quotes & pics from AtariAge page on Video Chess



## Atari 2600 Graphics

- Custom "Television Interface Adapter" for handling graphics and sound
- No graphics buffer!
- "Playfield" scanline 40 blocks wide, two colors
- Atari 2600 games have intricate timing loop
  - For each scanline, program has 76 cycles to do whatever computations it needs to do to load a scanline's worth of pixels into the TIA ("racing the beam")
  - Have to do most the "game logic" during the vertical blanking period
- Two sprite "players": 8-"pixel" wide chunks, twice resolution of playfield, could be two colors different than playfield
- Missiles: single-bit

Info from "Chris Crawford on Game Design"

Some details from Ian Bogost



## Atari 2600 - Graphics Tricks

- Could change TIA registers to change colors
  - ...from scan line to scan line
  - ...if you were extremely careful with your timing, you could do it in the middle of a scan line!
- Multiplex a single sprite between multiple objects
  - Flickering ghosts in Pac-Man
  - Flicker varies depending on number of ghosts in play
- Programmers learned to exploit "undocumented features" in the hardware
  - Makes the Atari 2600 one of the hardest machines to emulate accurately



## Rise of the third party developers

- Atari programmers unhappy
  - No credit
  - Salaried; little if any royalties
- Four top programmers split and form Activision (1979)
  - Responsible for over half of Atari's titles
  - Promoted game creators along with games
  - Drew top talent
  - Breakthrough product: Pitfall! (1982)
  - Didn't pay royalties to Atari
    - Nintendo learned from this!
  - Atari sued
  - Settled in 1982
- Mattel and Coleco made the same mistakes in handling their programmers that Atari did!



Georgia Institute of Technology

11

## Intellivision vs. Atari

- Plimpton Sports
  - <http://www.youtube.com/watch/v/IDza6eTXGEY>
- Major League Baseball
  - <http://www.youtube.com/watch/v/Y0KTjpaG3cg>
- Star Strike
  - [http://www.youtube.com/watch/v/VPB3H\\_a234s](http://www.youtube.com/watch/v/VPB3H_a234s)

Photo and info from Wikipedia

Georgia Institute of Technology

12

## Mattel Intellivision (1979)

- $\approx 1$  MHz General Instrument CP1610 (16-bit!)
- 1352 bytes RAM:
  - 240x8 scratchpad memory
  - 352x16 system memory
    - 240 words for character buffer – what characters are where and what color
  - 512x8 graphics memory
    - Character patterns
- 7168 bytes ROM
  - 4096x10 (5120) executive ROM
  - 2048x8 graphics ROM



Georgia Institute of Technology

11

Photo and info from Wikipedia

## Mattel Intellivision - Graphics

- 160x196, 16 colors
- 8 sprites
  - 8x8 or 8x16
  - Stretching: horizontal (1x, 2x) or vertical (1x, 2x, 4x, 8x)
  - Mirroring: horizontal and vertical
  - Collision detection: sprite to sprite, sprite to background, sprite to screen border
  - Priority: in front of or behind background

Photo and info from Wikipedia

Georgia Institute of Technology

12

## Mattel Intellivision - Retro

INTELLIVISION LIVES.COM

HOME NEWS DOWNLOADS HISTORY SUPPORT STORE CONTACT US

Game List  
Play Online NOW  
Post My Mag  
Newsletter  
Add link to Your MySpace

CLASSIC GAMING EXPO 2007 - JOIN US!!  
Written by Keith Robinson  
Tuesday, 03 July 2007

SEARCH: (GO)

Merchandise

Gaming News  
IGN Complete

SHOP INTELLIVISION

MOBILE

PlayStation 2

INTELLIVISION LIVES!

Georgia Institute of Technology

## Mattel Intellivision - Modern Homebrew Scene

jzIntv  
spatula-city.org/~im14u2c/intv

SDK-1600  
SOFTWARE DEVELOPERS KIT  
FOR THE INTELLIVISION™ VIDEO GAME SYSTEM  
sdk-1600.spatula-city.org

Homebrew programming contest:  
spatula-city.org/~im14u2c/intv/contest-2007

Joseph Zbiciak presents  
4-TRIS  
Copyright © 2000

LEVEL 004  
LINES 000  
000000 1005  
spatula-city.org/~im14u2c/intv/4-tris

Georgia Institute of Technology

## Example Intellivision code

```
CALL RSGGB ; Reset good guy bullets.
CALL FILLZERO.lp ; \
DECLS 25 ; | - nuke any remaining bad guys
DECLS BGMPTBL ; /

CALL FILLZERO.lp ; \
DECLS 10 ; | - and their sprites
DECLS SPAT ; /

; ; ----- ; ;
; ; Draw the crater strip in selected color scheme. ; ;
; ; ----- ; ;
MVI COURSE, R1 ; \
ANDI #7, R1 ; |
SLR R1, 1 ; | Adjust color for course
ADDI #CRATCLR, R1 ; |
ADD@ R1, R0 ; /
MOVR R0, R2 ; /
ADDI #7*8, R2 ; City/crater ending card #
```

Source code for Space Patrol  
From spatula-city.org/~im14u2c/intv/spteaser

Georgia Institute of Technology

## Atari Homebrew Scene

RANGER

ibogost

ian Bogost (LCC)

PLATFORM STUDIES

From [www.bogost.com](http://www.bogost.com) and [www.quernhorst.de/atari/rf.html](http://www.quernhorst.de/atari/rf.html)

Georgia Institute of Technology

## ColecoVision (1982)

- ≈3.6 MHz Zilog Z-80A (8-bit)
- 1KB scratch RAM
- 16 KB of separate VRAM (not directly CPU addressable)
- Cartridges 8/16/24/32K
- Expansion Module #1 allowed user to play Atari 2600 games
  - Atari sued, but lost since EM #1 used off-the-shelf hardware
- Bundled with Donkey Kong - “killer app”
- 6 million sold
- Discontinued 1984
- Coleco also produced games for Atari 2600 and Intellivision
- <http://www.youtube.com/v/5GpptJusOjM>



Info from Wikipedia

Georgia Institute of Technology

17

## ColecoVision - Graphics

- Video Processor: Texas Instruments TMS9928A
  - Variants used in MSX, Texas Instruments TI-99/4A
- 256x192, 15 colors
- 32 sprites (but only 4 per line)
- First console that could seriously compete with stand-alone arcade machines



Smurf: Rescue in Gargamel's Castle



War Room

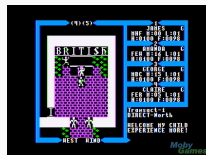
Info & screenshots from Wikipedia

Georgia Institute of Technology

18

## Apple ][ series (1977)

- ≈1 MHz MOS 6502
- 16K to 48K of RAM (64K with “Language Card”)
- Expansion slots
- VisiCalc (first spreadsheet) - killer app
- Spurred IBM to make the IBM PC
- Hi-res graphics: 280x192, 5 colors (sort of)
  - Page flipping, Pre-shifted shapes



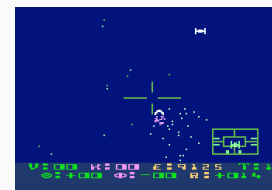
Exodus: Ultima III screenshot from Moby Games  
Other pics and info from Wikipedia

Georgia Institute of Technology

19

## Atari HCS 400/800 (1979)

- ≈1 MHz MOS 6502
- 16K to 48K of RAM
- Star Raiders - “killer app”
  - Created by engineer who designed POKEY (the I/O and sound chip)
  - Written to show off the machine's capabilities
  - 3-D math!!! Remember, no divide instructions....



Star Raiders



Pics and info from Wikipedia

Georgia Institute of Technology

20

## Atari HCS 400/800 - Graphics

- Extremely flexible graphics system
- Amenable to all kinds of 2600-style tricks, although now with a much more powerful basic capabilities
  - Reprogramming color table for each scan line
  - Vertical smooth scrolling easy
  - Smooth scrolling horizontally via custom character set patterns



Eastern Front (1941)



Caverns of Mars

Info from "Chris Crawford on Game Design"  
Screenshots from Wikipedia

Georgia Institute of Technology

21

## Atari 5200 (1982)

- Sort of a Atari 400/800 without a keyboard
- Not totally compatible
- Had trouble with new analog joysticks
  - Hard to center
- Atari paid more attention to 2600 line
- Discontinued in 1984



Rescue on Fractalus!



Photo and info from Wikipedia

Georgia Institute of Technology

22

## Commodore 64 (1982)

- $\approx 1$  MHz MOS 6510 (close relative of 6502)
- 64K RAM
- Discontinued 1984
  - Followed up by many variations
- Classic sound chip: SID
- Launch price: \$595



Photo and info from Wikipedia

Georgia Institute of Technology

23

## Commodore 64 - Graphics

- MOS VIC-II graphics chip
- 16 colors
- Display modes:
  - 320x200 (2 unique colors in each 8x8 pixel block)
  - 160x200 (3 unique colors + 1 common color in each 4x8 pixel block)
- 8 sprites, 24x21 pixels (12x21 in multicolor mode)
- Smooth scrolling
- Raster interrupts

Info from Wikipedia

Georgia Institute of Technology

24

## The Video Game Crash of 1984 (1)

- Partially arose from a cascade effect of Atari's hubris
- E.T. rushed to market in only 5 weeks to hit stores in time for holiday season
  - <http://www.youtube.com/v/VakiwDmJ-II>
  - Widely considered Worst Game Ever
  - Atari paid \$20-25 million for the rights
  - 1.5 million sold
    - 8th best selling Atari cartridge of all time
  - 4 million manufactured
- Rushed, weak port of Pac-Man
  - 12 million manufactured
  - Only 10 million Ataris in homes at the time
    - Atari assumed people would buy 2600s to play Pac-Man
  - 7 million sold
  - Ms. Pac-Man port & homebrew Pac-Mans are better

Photo and info from Wikipedia

## The Video Game Crash of 1984 (2)

- Millions of cartridges of E.T. and Pac-Man encased in concrete and secretly dumped in landfill
- In 1982, Atari CEO Ray Kassar sells off 5,000 of his Warner (Atari's parent company) stock just before a low earnings report drops Warner stock by 40%
  - SEC investigated for insider trading
  - Settled, returned profits
  - Later cleared by SEC
  - Forced to resign in 1983

Info from Wikipedia

## Nintendo NES (1985 U.S. release)

- ≈1.8 MHz 6502 core, with DMA controller and sound hardware on-die (Ricoh)
- Called "Famicom" in most of Asia (1983 in Japan)
- Bundled with Super Mario Bros. - "killer app"
- Launch price: \$200; final bundle: \$50
- Discontinued in 1995
- 62 million sold
- Competition:
  - Sega SG-1000 (1985 Japan)
  - Renamed Sega Master System (1986 U.S.)
    - Didn't catch on in the U.S.
  - Atari 7800 - last gasp, bombed



Pics and info from Wikipedia

## Nintendo NES - Graphics

- Ricoh-made "Picture Processing Unit"
  - ≈5.4 MHz, RP2C02
- 256x240 resolution
- 64 sprites (8x8 or 8x16 for all), 8 per scanline
- Tile patterns
- 25 colors per scanline:
  - 1 background
  - 4 sets of 3 tile colors
  - 4 sets of 3 sprite colors

Photo and info from wikipedia

## Sega vs. Nintendo

- Blast Processing
  - <http://www.youtube.com/v/K03fQKkN7VI>
- Genesis Does what Nintendo doesn't
  - <http://www.youtube.com/v/k7nsBoqJ6s8>

## Sega Genesis (1989)

- ≈7 MHz Motorola 68000
- ≈3.5 MHz Zilog Z80
  - Sound coprocessor
  - Backward compatibility with Sega Master System
- 64K main RAM for 68000
- 64K video RAM (not directly accessible)
- 8K secondary RAM for Z80
- 8K audio RAM
- ROM cartridges up to 4M
  - Can use bank switching for larger games
- Released as “Sega Mega Drive” in Japan (1988)
- 29 million sold



Photo and info from Wikipedia

## Sega Genesis - Video

- “Video Display Processor” – descendent of the TMS9928 family used in Colecovision (but not designed by TI)
- 320x224 resolution (complicated)
- 4 planes (2 scrolling playfields, 1 sprite plane, 1 ‘window’ plane)
- Up to 64 sprites
- 61 on-screen colors
- Nintendo’s answer, the Super NES, came later
  - 1990 Japan, 1991 U.S.
  - 49 million sold
  - Slower CPU, but nice graphics & audio chips



Most info from Wikipedia  
TMS9928 note from Joe Zbiciak

## IBM PC compatibles

- Original IBM PC (1981)
  - ≈4.8 MHz 8088
  - 16K to 640K
  - CGA (640x200 B&W, 320x200 4-color, 160x100 16-color w/tricks)
- IBM PC AT (1984)
  - 6 MHz 80286, later 8 MHz
  - 256K to 16M
  - EGA (640x350 16-color from a palette of 64)
- VGA (1987)
  - Palette of 262,18 colors
  - 640x480, 16-colors
  - 320x200, 64-colors (Wolfenstein 3-D)
  - 320x240, 64-colors (Doom)
- Killer app: Lotus 123



Photo and info from Wikipedia  
Some details by Joe Zbiciak

## Doom (1993)

- Followed in footsteps of Wolfenstein 3-D (1992)
- Released as shareware!
  - Downloaded by 10 million people in two years
- Cleverness over hardware



John Carmack



Images and info from Wikipedia

Georgia Institute of Technology

33