

CPSC 599.82 – Retrogames (Winter/2014)

Tutorial on Stella Atari 2600 Emulator

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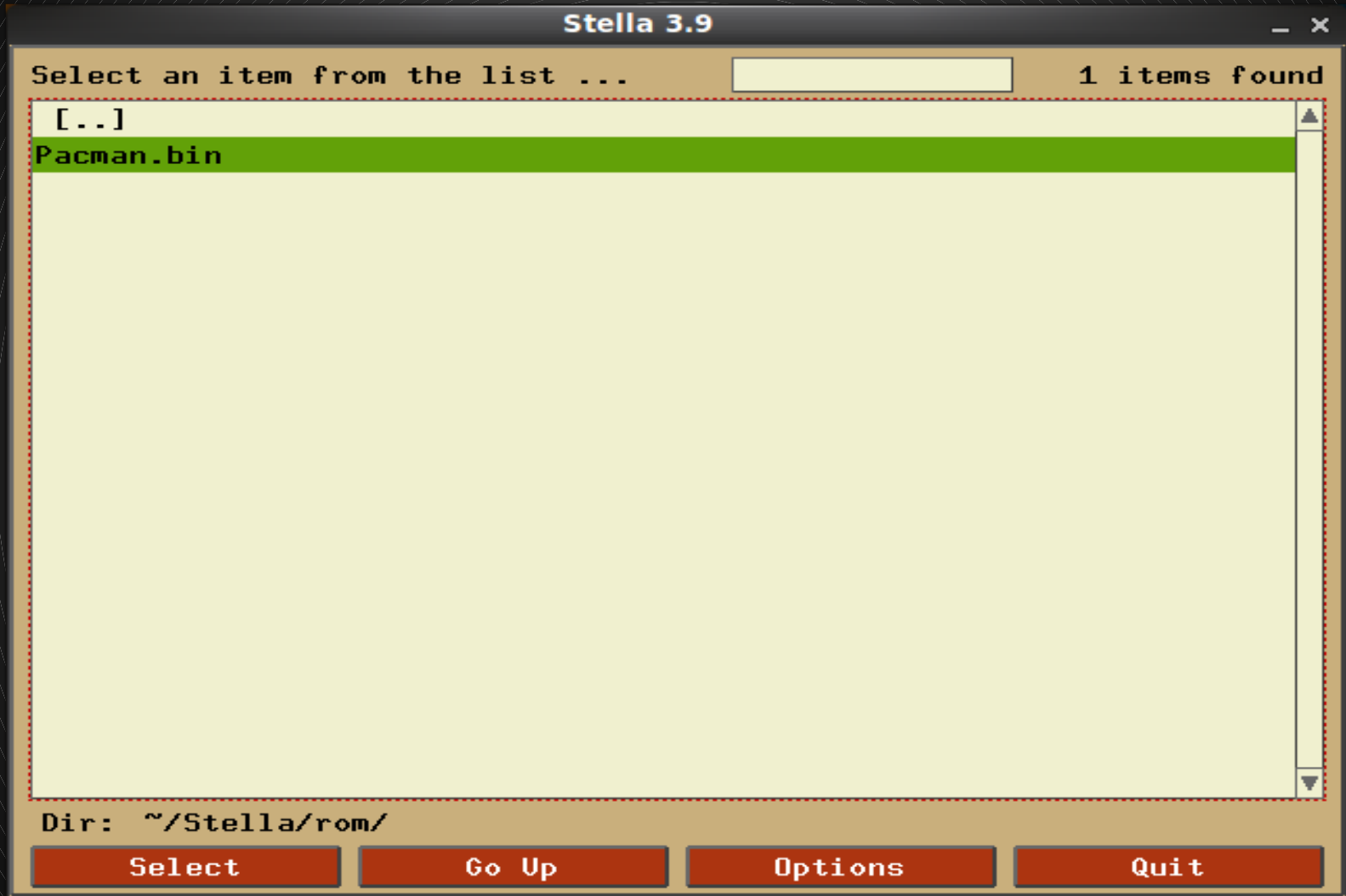
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Meet the console



Meet the emulator



Meet the Debugger

The screenshot displays the Stella debugger interface. On the left, a Pac-Man game is running, showing the maze and the character. The top right panel shows game state: Frame: 959, Scanline: 262, F. Cyc: 19912, S. Cyc: 5, VSync, Pixel Pos: -53, VBlank, Color Clk: 15. The CPU registers are shown: PC: F87E, SP: FF, A: 29, X: 00, Y: 17, PS: n v - B d I Z c. The memory dump shows the current address (ram_80) and its contents in hexadecimal and decimal. The command prompt shows the execution of 'autoExec()' and the resulting error messages.

Frame: 959 Scanline: 262
 F. Cyc: 19912 S. Cyc: 5
 VSync Pixel Pos: -53
 VBlank Color Clk: 15

PC: F87E
 SP: FF 255 11111111 00
 A: 29 41 00101001 00
 X: 00 0 00000000 00
 Y: 17 23 00010111 80
 PS: n v - B d I Z c Src Addr

00xx	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
80	BF	00	00	00	06	00	00	2E	FC	8F	EE	E8	07	F7	77	19
90	F3	86	F7	F7	C3	2F	EF	E3	03	08	3C	0A	00	00	00	00
A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	09
B0	64	18	52	2A	64	2A	32	46	0A	3E	32	00	40	40	80	40
C0	69	C7	08	17	08	02	04	03	02	05	00	61	42	00	00	00
D0	00	00	00	A0	00	00	00	00	00	FE	3D	FE	07	06	A3	FD
E0	FD	FF	00	00	00	00	00	00	00	00	00	00	09	00	BA	FF
F0	07	08	DC	FB	09	C4	12	FB	01	FB	EA	35	A9	F7	D0	F7

Label: ram_80 Dec: 191 Bin: 10111111

Disassembly Cartridge4K

Bank state: 0 (non-bankswitched)

Address	Op	Operand	Count	Next
F87E	LDA	ram_9B	:3	A5 9B
F880	STA	ram_F5	:3	85 F5
F882	LDA	ram_82	:3	A5 82
F884	BEQ	LF88A	:2	F0 04
F886	LDA	INPT4I\$30	:3	A5 3C
F888	BPL	LF890	:2	10 06
LF88A	LDA	SWCHB	:4	AD 82 02
F88D	ROR		:2	6A
F88E	BCS	LF8C1	:2	B0 31
LF890	LDA	#\$FF	:2	A9 FF
F892	STA	ram_CB	:3	85 CB
F894	JSR	LFC7D	:6	20 7D FC
F897	STA	ram_AC	:3	85 AC
F899	STA	ram_82	:3	85 82
F89B	LDA	#\$08	:2	A9 08
F89D	STA	ram_E7	:3	85 E7
F89F	LDA	#\$0B	:2	A9 0B
F8A1	LDX	ram_84	:3	A6 84
F8A3	CPX	#\$08	:2	E0 08
F8A5	BPL	LF8A9	:2	10 02
F8A7	LDA	#\$09	:2	A9 09
LF8A9	STA	ram_C0	:3	85 C0
F8AB	JSR	LFBF4	:6	20 F4 FB
F8AE	LDA	ram_E6	:3	A5 E6
F8B0	AND	#\$7F	:2	29 7F

```

Stella 3.9
> autoExec();
autoexec file '~/stella/autoexec.stella' not found
autoexec file '~/Stella/AtariAge/Pacman.stella' not found
config file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).cfg
~/stella/cfg/Pac-Man (1982) (Atari).cfg
symbol file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).sym
>
    
```

Meet the Debugger: Prompt area

The screenshot displays a debugger interface for an Atari game. The top-left window shows a Pac-Man maze. The top-right window shows game statistics: Frame: 959, Scanline: 262, F. Cyc: 19912, S. Cyc: 5, VSync, Pixel Pos: -53, VBlank, and Color Clk: 15. The right side of the interface shows the PC: F87E, SP: FF, A: 29, X: 00, Y: 17, and PS: n v - B d I Z c. Below this is a memory dump table with columns 00xx, 0-15, and A-F. The disassembly window shows instructions starting with LDA ram_9B. The prompt area at the bottom left shows the following text:

```
Stella 3.9
> autoExec();
autoexec file '~/stella/autoexec.stella' not found
autoexec file '~/Stella/AtariAge/Pacman.stella' not found
config file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).cfg
~/stella/cfg/Pac-Man (1982) (Atari).cfg
symbol file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).sym
>
```


Meet the Debugger: TIA (Display, Info and Zoom)

The screenshot displays the Stella debugger interface for the Atari game Pac-Man. The main window shows a maze with the Pac-Man character and a ghost. A zoomed-in view of the maze is shown in the bottom right. The top right panel displays system information and controls.

System Information:

- Frame: 959 Scanline: 262
- F. Cyc: 19912 S. Cyc: 5
- VSync Pixel Pos: -53
- VBlank Color Clk: 15

Registers and Memory:

PC: F87E
 SP: FF 255 11111111 00
 A: 29 41 00101001 00
 X: 00 0 00000000 00
 Y: 17 23 00010111 80

PS: n v - B d I Z c Src Addr

Memory Dump:

00xx	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
80	BF	00	00	00	06	00	00	2E	FC	8F	EE	E8	07	F7	77	19
90	F3	86	F7	F7	C3	2F	EF	E3	03	08	3C	0A	00	00	00	00
A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	09
B0	64	18	52	2A	64	2A	32	46	0A	3E	32	00	40	40	80	40
C0	69	C7	08	17	08	02	04	03	02	05	00	61	42	00	00	00
D0	00	00	00	A0	00	00	00	00	00	FE	3D	FE	07	06	A3	FD
E0	FD	FF	00	00	00	00	00	00	00	00	00	00	09	00	BA	FF
F0	07	08	DC	FB	09	C4	12	FB	01	FB	EA	35	A9	F7	D0	F7

Disassembly:

Label: ram_80 Dec: 191 Bin: 10111111

Disassembly Cartridge4K

Bank state: 0 (non-bankswitched)

Address	OpCode	OpName	OpSize	OpData
F87E	LDA	ram_9B	:3	A5 9B
F880	STA	ram_F5	:3	85 F5
F882	LDA	ram_82	:3	A5 82
F884	BEQ	LF88A	:2	F0 04
F886	LDA	INPT4I\$30	:3	A5 3C
F888	BPL	LF890	:2	10 06
LF88A	LDA	SWCHB	:4	AD 82 02
F88D	ROR		:2	6A
F88E	BCS	LF8C1	:2	B0 31
LF890	LDA	#\$FF	:2	A9 FF
F892	STA	ram_CB	:3	85 CB
F894	JSR	LF87D	:6	20 7D FC
F897	STA	ram_AC	:3	85 AC
F899	STA	ram_82	:3	85 82
F89B	LDA	#\$08	:2	A9 08
F89D	STA	ram_E7	:3	85 E7
F89F	LDA	#\$0B	:2	A9 0B
F8A1	LDX	ram_84	:3	A6 84
F8A3	CPX	#\$08	:2	E0 08
F8A5	BPL	LF8A9	:2	10 02
F8A7	LDA	#\$09	:2	A9 09
LF8A9	STA	ram_C0	:3	85 C0
F8AB	JSR	LFBF4	:6	20 F4 FB
F8AE	LDA	ram_E6	:3	A5 E6
F8B0	AND	#\$7F	:2	29 7F

Command Prompt:

```
Stella 3.9
> autoExec();
autoexec file '~/stella/autoexec.stella' not found
autoexec file '~/Stella/AtariAge/Pacman.stella' not found
config file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).cfg
~/stella/cfg/Pac-Man (1982) (Atari).cfg
symbol file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).sym
>
```

Meet the Debugger: CPU Registers

The screenshot displays a debugger interface for an Atari game. The top-left pane shows a game frame with a score of 42. The top-right pane shows CPU registers: PC: FB7E, SP: FF, A: 29, X: 00, Y: 17, and PS: n v - B d I Z c. The middle-right pane shows a memory dump starting at address 80. The bottom-left pane shows the command prompt with error messages for autoExec(). The bottom-right pane shows the disassembly of the current instruction at address FB7E: LDA ram_9B.

Debugger Settings:

- Frame: 959 Scanline: 262
- F. Cyc: 19912 S. Cyc: 5
- VSync Pixel Pos: -53
- VBlank Color Clk: 15

Register Values:

PC:	FB7E		
SP:	FF	255	11111111
A:	29	41	00101001
X:	00	0	00000000
Y:	17	23	00010111
PS:	n v - B d I Z c		

Memory Dump (00xx):

00xx	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
80	BF	00	00	00	06	00	00	2E	FC	8F	EE	E8	07	F7	77	19
90	F3	86	F7	F7	C3	2F	EF	E3	03	08	3C	0A	00	00	00	00
A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	09
B0	64	18	52	2A	64	2A	32	46	0A	3E	32	00	40	40	80	40
C0	69	C7	08	17	08	02	04	03	02	05	00	61	42	00	00	00
D0	00	00	00	A0	00	00	00	00	00	FE	3D	FE	07	06	A3	FD
E0	FD	FF	00	00	00	00	00	00	00	00	00	00	09	00	BA	FF
F0	07	08	DC	FB	09	C4	12	FB	01	FB	EA	35	A9	F7	D0	F7

Disassembly:

```

Label: ram_80      Dec: 191      Bin: 10111111
Disassembly      Cartridge4K
Bank state: 0 (non-bankswitched)
FB7E             LDA      ram_9B      ;3      A5 9B
F880             STA      ram_F5      ;3      85 F5
F882             LDA      ram_82      ;3      A5 82
F884             BEQ      LF88A       ;2      F0 04
F886             LDA      INPT4I$30   ;3      A5 3C
F888             BPL      LF890       ;2      10 06
LF88A           LDA      SWCHB       ;4      AD 82 02
F88D             ROR      ;2          6A
F88E             BCS      LF8C1       ;2      B0 31
LF890           LDA      #$FF        ;2      A9 FF
F892             STA      ram_CB      ;3      85 CB
F894             JSR      LFC7D       ;6      20 7D FC
F897             STA      ram_AC      ;3      85 AC
F899             STA      ram_82      ;3      85 82
F89B             LDA      #$08        ;2      A9 08
F89D             STA      ram_E7      ;3      85 E7
F89F             LDA      #$0B        ;2      A9 0B
F8A1             LDX      ram_84      ;3      A6 84
F8A3             CPX      #$08        ;2      E0 08
F8A5             BPL      LF8A9       ;2      10 02
F8A7             LDA      #$09        ;2      A9 09
LF8A9           STA      ram_C0      ;3      85 C0
F8AB             JSR      LFBF4       ;6      20 F4 FB
F8AE             LDA      ram_E6      ;3      A5 E6
F8B0             AND      #$7F        ;2      29 7F
    
```

Command Prompt:

```

Stella 3.9
> autoExec();
autoexec file '~/stella/autoexec.stella' not found
autoexec file '~/Stella/AtariAge/Pacman.stella' not found
config file not found in:
  ~/Stella/AtariAge/Pac-Man (1982) (Atari).cfg
  ~/stella/cfg/Pac-Man (1982) (Atari).cfg
symbol file not found in:
  ~/Stella/AtariAge/Pac-Man (1982) (Atari).sym
>
    
```

Meet the Debugger: RAM

The screenshot displays the Stella debugger interface for an Atari game. The top-left pane shows a Pac-Man maze with the character and a score of 42. The top-right pane shows system status: Frame: 959, Scanline: 262, F. Cyc: 19912, S. Cyc: 5, VBlank checked, Color Clk: 15. The middle-right pane shows a memory dump for PC: F87E, with registers SP, A, X, Y, and PS. Below this is a hex dump of memory from 80 to F0, with the current address ram_80 highlighted. The bottom-left pane shows the command prompt with error messages for missing files. The bottom-right pane shows the disassembly window for Cartridge4K, displaying instructions like LDA ram_9B, STA ram_F5, etc.

Frame: 959 Scanline: 262
 F. Cyc: 19912 S. Cyc: 5
 VSync Pixel Pos: -53
 VBlank Color Clk: 15

PC: F87E
 SP: FF 255 11111111 00
 A: 29 41 00101001 00
 X: 00 0 00000000 00
 Y: 17 23 00010111 80
 PS: n v - B d I Z c Src Addr

00xx	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
80	BF	00	00	00	06	00	00	2E	FC	8F	EE	E8	07	F7	77	19
90	F3	86	F7	F7	C3	2F	EF	E3	03	08	3C	0A	00	00	00	00
A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	09
B0	64	18	52	2A	64	2A	32	46	0A	3E	32	00	40	40	80	40
C0	69	C7	08	17	08	02	04	03	02	05	00	61	42	00	00	00
D0	00	00	00	A0	00	00	00	00	00	FE	3D	FE	07	06	A3	FD
E0	FD	FF	00	00	00	00	00	00	00	00	00	00	09	00	BA	FF
F0	07	08	DC	FB	09	C4	12	FB	01	FB	EA	35	A9	F7	D0	F7

Label: ram_80 Dec: 191 Bin: 10111111

Disassembly Cartridge4K
 Bank state: 0 (non-bankswitched)

Address	Instruction	Comment	Count	Next Address
F87E	LDA ram_9B		:3	A5 9B
F880	STA ram_F5		:3	85 F5
F882	LDA ram_82		:3	A5 82
F884	BEQ LF88A		:2	F0 04
F886	LDA INPT4I\$30		:3	A5 3C
F888	BPL LF890		:2	10 06
LF88A	LDA SWCHB		:4	AD 82 02
F88D	RDR		:2	6A
F88E	BCS LF8C1		:2	B0 31
LF890	LDA #\$FF		:2	A9 FF
F892	STA ram_CB		:3	85 CB
F894	JSR LFC7D		:6	20 7D FC
F897	STA ram_AC		:3	85 AC
F899	STA ram_82		:3	85 82
F89B	LDA #\$08		:2	A9 08
F89D	STA ram_E7		:3	85 E7
F89F	LDA #\$0B		:2	A9 0B
F8A1	LDX ram_84		:3	A6 84
F8A3	CPX #\$08		:2	E0 08
F8A5	BPL LF8A9		:2	10 02
F8A7	LDA #\$09		:2	A9 09
LF8A9	STA ram_C0		:3	85 C0
F8AB	JSR LFBF4		:6	20 F4 FB
F8AE	LDA ram_E6		:3	A5 E6
F8B0	AND #\$7F		:2	29 7F

Prompt TIA I/O Audio
 Stella 3.9
 > autoExec();
 autoexec file '~/stella/autoexec.stella' not found
 autoexec file '~/Stella/AtariAge/Pacman.stella' not found
 config file not found in:
 ~/Stella/AtariAge/Pac-Man (1982) (Atari).cfg
 ~/stella/cfg/Pac-Man (1982) (Atari).cfg
 symbol file not found in:
 ~/Stella/AtariAge/Pac-Man (1982) (Atari).sym
 >

Meet the Debugger: Disassembly

The screenshot displays a debugger interface for an Atari game. The top-left pane shows a game frame with a score of 42. The top-right pane shows system information: Frame: 959, Scanline: 262, F. Cyc: 19912, S. Cyc: 5, VSync, Pixel Pos: -53, VBlank, and Color Clk: 15. The middle-right pane shows registers: PC: F87E, SP: FF, A: 29, X: 00, Y: 17, and PS: n v - B d I Z c. Below the registers is a memory dump table with columns for address (00xx) and hex values.

00xx	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
80	BF	00	00	00	06	00	00	2E	FC	8F	EE	E8	07	F7	77	19
90	F3	86	F7	F7	C3	2F	EF	E3	03	08	3C	0A	00	00	00	00
A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	09
B0	64	18	52	2A	64	2A	32	46	0A	3E	32	00	40	40	80	40
C0	69	C7	08	17	08	02	04	03	02	05	00	61	42	00	00	00
D0	00	00	00	A0	00	00	00	00	00	FE	3D	FE	07	06	A3	FD
E0	FD	FF	00	00	00	00	00	00	00	00	00	00	09	00	BA	FF
F0	07	08	DC	FB	09	C4	12	FB	01	FB	EA	35	A9	F7	D0	F7

The bottom-left pane shows the command prompt with the following text:

```
Stella 3.9
> autoExec();
autoexec file '~/stella/autoexec.stella' not found
autoexec file '~/Stella/AtariAge/Pacman.stella' not found
config file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).cfg
~/stella/cfg/Pac-Man (1982) (Atari).cfg
symbol file not found in:
~/Stella/AtariAge/Pac-Man (1982) (Atari).sym
>
```

The bottom-right pane shows the disassembly window for Cartridge4K, Bank state: 0 (non-bankswitched). The disassembly list is as follows:

Address	OpCode	Operand	Count	Next PC
F87E	LDA	ram_9B	:3	A5 9B
F880	STA	ram_F5	:3	85 F5
F882	LDA	ram_82	:3	A5 82
F884	BEQ	LF88A	:2	F0 04
F886	LDA	INPT4I\$30	:3	A5 3C
F888	BPL	LF890	:2	10 06
LF88A	LDA	SWCHB	:4	AD 82 02
F88D	ROR		:2	6A
F88E	BCS	LF8C1	:2	B0 31
LF890	LDA	#\$FF	:2	A9 FF
F892	STA	ram_CB	:3	85 CB
F894	JSR	LF87D	:6	20 7D FC
F897	STA	ram_AC	:3	85 AC
F899	STA	ram_82	:3	85 82
F89B	LDA	#\$08	:2	A9 08
F89D	STA	ram_E7	:3	85 E7
F89F	LDA	#\$0B	:2	A9 0B
F8A1	LDX	ram_84	:3	A6 84
F8A3	CPX	#\$08	:2	E0 08
F8A5	BPL	LF8A9	:2	10 02
F8A7	LDA	#\$09	:2	A9 09
LF8A9	STA	ram_C0	:3	85 C0
F8AB	JSR	LFBF4	:6	20 F4 FB
F8AE	LDA	ram_E6	:3	A5 E6
F8B0	AND	#\$7F	:2	29 7F

Before we continue...

A hint/suggestion for some laptop users



Let's hack Pac Man

- Goal: Get infinite lives
- First step: Locate lives in memory
 - Sub tasks: Search memory location, add more lives to confirm it, document it.
- Second: Never lose a life again
 - Sub tasks: Locate the relevant code, change it, test it, save it.

Where are my lives?

- Manual method
 - Look at the RAM (128 bytes, it's not too hard)
 - More difficult if you had extra memory
- Dynamic method
 - “Search” for value
 - Force the value to change (Kill Pac Man)
 - Compare
 - Unfortunately, it seems to be buggy! :(

Adding documentation

- “define” labels
 - Pro: Updates the disassembled code
 - Con: It's not persistent
- Making notes
 - Use your favorite text editor
 - Simple and persistent solution
 - Special file: <game name>.sym,
 - Where <game name> is given by Stella
 - Works as labels
 - Reload using “loadsym” (removed in 3.9.1)

Hacking the code

- Need to identify the code before performing any changes
- Manual approach
 - Save the disassembled code: savedis
 - Stella 3.9.3 for Windows requires that the file already exists(!?)
 - Search for it
- Dynamic approach
 - Let the Debugger find it for you
(Breakpoints, Watchpoints and Traps)

Stopping the code

- **Breakpoints**

- Stops when PC gets there (break)
- Conditional: Stops when something happens (breakif)



- **Watches**

- Evaluate and prints expression before prompt (watch)

- **Trap**

- Stops when a memory is read (trapread), written (trapwrite) or accessed (trap)

Breakpoint/Trap Status

Frame: 959 Scanline: 262
 F. Cyc: 19912 S. Cyc: 5
 VSync Pixel Pos: -53
 VBlank Color Clk: 15

PC: F87E
 SP: FF 255 11111111 00
 A: 29 41 00101001 00
 X: 00 0 00000000 00
 Y: 17 23 00010111 80

PS: n v - B d I Z c Src Addr

00xx	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
80	BF	00	00	00	06	00	00	2E	FC	8F	EE	E8	07	F7	77	19
90	F3	86	F7	F7	C3	2F	EF	E3	03	08	3C	0A	00	00	00	00
A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	09
B0	64	18	52	2A	64	2A	32	46	0A	3E	32	00	40	40	80	40
C0	69	C7	08	17	08	02	04	03	02	05	00	61	42	00	00	00
D0	00	00	00	A0	00	00	00	00	00	FE	3D	FE	07	06	A3	FD
E0	FD	FF	00	00	00	00	00	00	00	00	00	00	09	00	BA	FF
F0	07	08	DC	FB	09	C4	12	FB	01	FB	EA	35	A9	F7	D0	F7

Step
Trace
Scan +1
Frame +1
Exit

Search

Label: ram_80 Dec: 191 Bin: 10111111

Disassembly Cartridge4K

Bank state: 0 (non-bankswitched)

Address	Op	Operand	Count	Next
F87E	LDA	ram_9B	:3	A5 9B
F880	STA	ram_F5	:3	85 F5
F882	LDA	ram_82	:3	A5 82
F884	BEQ	LF88A	:2	F0 04
F886	LDA	INPT4I\$30	:3	A5 3C
F888	BPL	LF890	:2	10 06
LF88A	LDA	SWCHB	:4	AD 82 02
F88D	RDR		:2	6A
F88E	BCS	LF8C1	:2	B0 31
LF890	LDA	#\$FF	:2	A9 FF
F892	STA	ram_CB	:3	85 CB
F894	JSR	LF87D	:6	20 7D FC
F897	STA	ram_AC	:3	85 AC
F899	STA	ram_82	:3	85 82
F89B	LDA	#\$08	:2	A9 08
F89D	STA	ram_E7	:3	85 E7
F89F	LDA	#\$0B	:2	A9 0B
F8A1	LDX	ram_84	:3	A6 84
F8A3	CPX	#\$08	:2	E0 08
F8A5	BPL	LF8A9	:2	10 02
F8A7	LDA	#\$09	:2	A9 09
LF8A9	STA	ram_C0	:3	85 C0
F8AB	JSR	LFBF4	:6	20 F4 FB
F8AE	LDA	ram_E6	:3	A5 E6
F8B0	AND	#\$7F	:2	29 7F

Prompt TIA I/O Audio

Stella 3.9
 > autoExec();
 autoexec file '~/stella/autoexec.stella' not found
 autoexec file '~/Stella/AtariAge/Pacman.stella' not found
 config file not found in:
 ~/Stella/AtariAge/Pac-Man (1982) (Atari).cfg
 ~/stella/cfg/Pac-Man (1982) (Atari).cfg
 symbol file not found in:
 ~/Stella/AtariAge/Pac-Man (1982) (Atari).sym
 > █

Let's hack it!

Summary

- Overview of the Debugger
 - Configuration (optional)
- Change memory (RAM and ROM)
- Some useful commands:
 - define, loadsym (note: loadsym was removed from 3.9.1 and newer)
 - frame, scanline, trace, step
 - break, breakif, watch, trapread, trapwrite, trap
 - savedis, saverom
- References:
 - <http://stella.sourceforge.net/docs/debugger.html>
 - <http://www.atariarchives.org/alp/> (6502 Assembly language)

Appendix A – Some Assembly instructions

Inst	Description		Inst	Description
NOP	No operation		SEC	Set the carry bit
STA	Store A to memory		SBC	Subtract with carry
STX	Store X to memory		CLC	Clear the carry bit
STY	Store Y to memory		ADC	Add with carry
LDA	Load memory to A		CMP	Compare memory and A
LDX	Load memory to X		CPX	Compare memory and X
LDY	Load memory to Y		CPY	Compare memory and Y
INC	Add memory		EOR	Exclusive OR with A
DEC	Decrement memory		BCC	Branch when carry is clear
JMP	Jump to address		BCS	Branch when carry is set
JSR	Jump to subroutine		BEQ	Branch when zero bit is set
RTS	Return from subroutine		BNE	Branch when zero is clear