NES Programming in Rust

Sydney Rust Meetup 2023-03-01
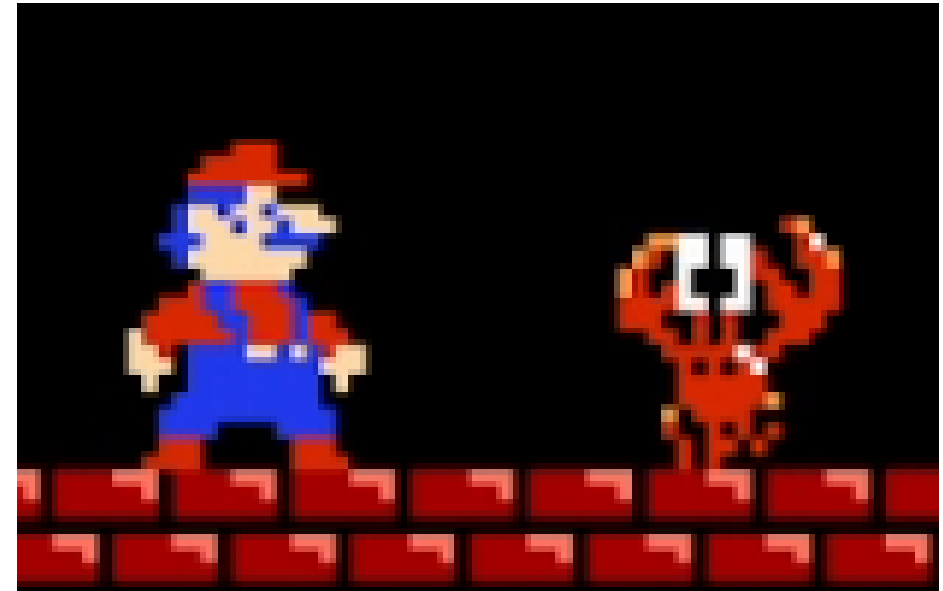
Stephen Sherratt (@gridbugs)

gridbugs.org

github.com/gridbugs

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Demo (video) 🤞🤞🤞

https://youtu.be/QHoISiWdPXo

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About

Tool for generating NES ROM files giving control over the bits in the APU's registers

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Releases

No releases published

Packages

No packages published

Languages

● **Rust** 99.7%   ● **Nix** 0.3%

≣ **README.md**

NES Audio Playground

A tool for generating NES ROM files give access to the Audio Processing Unit's registers. Move the cursor with the d-pad, press A to flip a bit, and hold B to defer any bit flips until after B is released. Releasing B also has the side effect of rewriting the current value of the register under the cursor.

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<> **Code**   Issues   Pull requests   Actions   Projects   Security   Insights

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About

Tool for generating NES ROM files giving control over the bits in the APU's registers

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≡ README

NES

A tool for g
cursor with
Releasing

Languages

● **Rust** 99.7%   ● **Nix** 0.3%

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Usage

```
cargo run -- -o playground.nes    # generate ROM file
fceux playground.nes              # run ROM in NES emulator
```

Usage

```rust
use std::io::Write;
use ines::{Ines, Header};

let ines = Ines {
    header: Header { ... },
    chr_rom: chr_rom(), // tiles and sprites
    prg_rom: prg_rom(), // code and static data
};

let mut data = Vec::new();
ines.encode(&mut data);

let mut file = std::fs::File::create(output_path).unwrap();
file.write_all(&data).expect("Failed to write ROM file");
```
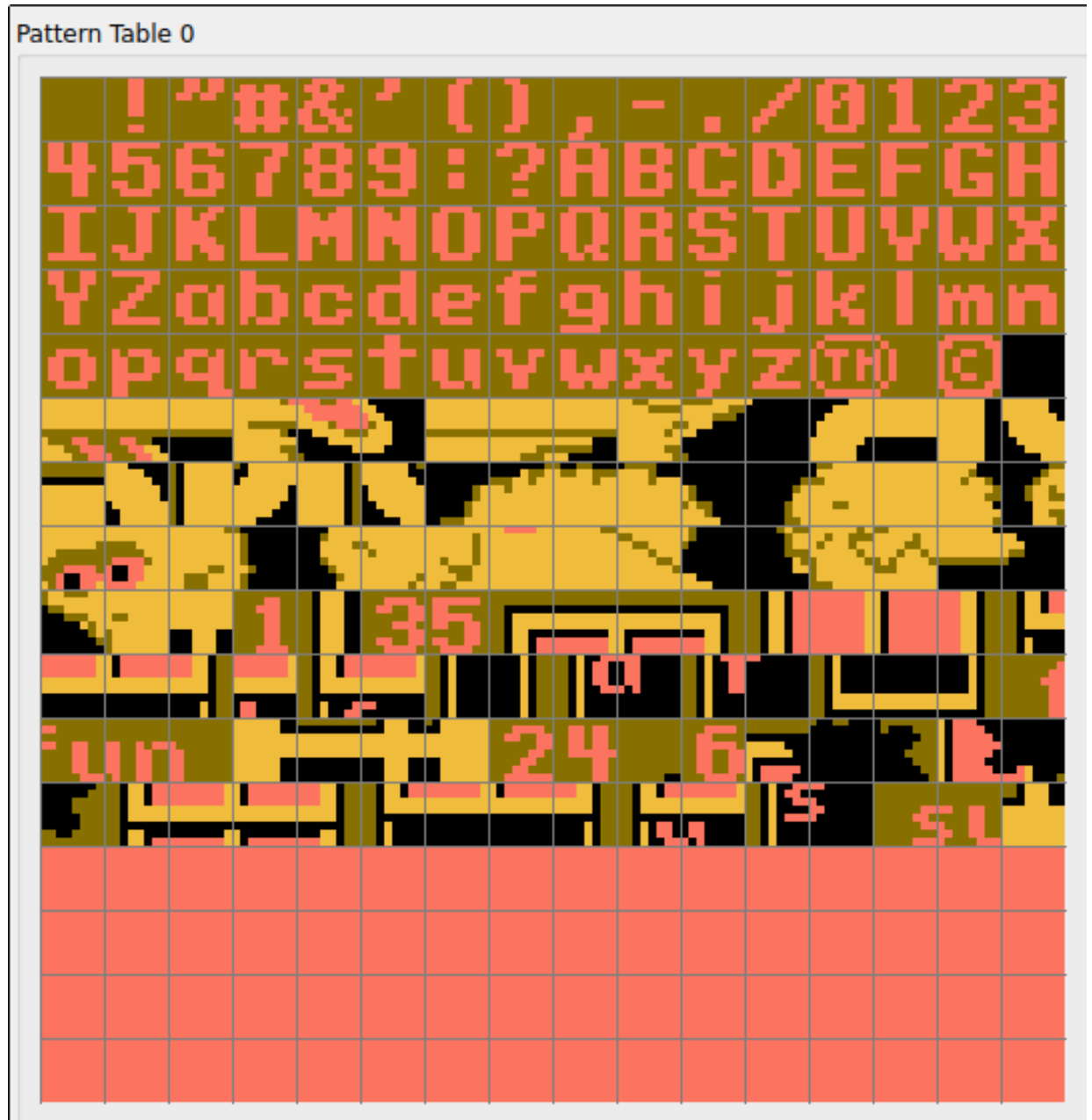
Character ROM

```
...
// 24: A
0b00111100,
0b01100110,
0b01100110,
0b01111110,
0b01100110,
0b01100110,
0b01100110,
...
```

Program ROM: Block

```rust
use mos6502_assembler::Block;

fn prg_rom() -> Vec<u8> {
    // A Block is an intermediate representation that keeps track of labels
    // and a cursor so you can put code/data at specific addresses.
    let mut b = Block::new();

    ...
}
```

ROM info from fceux NES emulator


```
Loading Sesame Street - Big Bird's Hide & Speak (USA).nes...

 PRG ROM: 16 x 16KiB = 256 KiB
 CHR ROM: 16 x  8KiB = 128 KiB
 ROM CRC32: 0xfde1c7ed
 ROM MD5:  0xe11377293fff45358d99aee90f98cbd6
 Mapper #: 1
 Mapper name: MMC1
 Mirroring: Horizontal
 Battery-backed: No
 Trained: No
```

Program ROM: Block

```rust
use mos6502_assembler::Block;

fn prg_rom() -> Vec<u8> {
    // A Block is an intermediate representation that keeps track of labels
    // and a cursor so you can put code/data at specific addresses.
    let mut b = Block::new();

    ...
}
```

Program ROM: Code/Data in EDSL

```rust
use mos6502_assembler::Block;

fn prg_rom() -> Vec<u8> {
    // A Block is an intermediate representation that keeps track of labels
    // and a cursor so you can put code/data at specific addresses.
    let mut b = Block::new();

    // describe program with EDSL
    b.inst(...);
    b.label(...);
    b.literal_byte(...);
    // ...etc

    ...
}
```

Program ROM: Assemble

```rust
use mos6502_assembler::Block;

fn prg_rom() -> Vec<u8> {
    // A Block is an intermediate representation that keeps track of labels
    // and a cursor so you can put code/data at specific addresses.
    let mut b = Block::new();

    // describe program with EDSL
    b.inst(...);
    b.label(...);
    b.literal_byte(...);
    // ...etc

    // convert from intermediate representation to byte array
    // (this pass is needed to resolve labels)
    let mut prg_rom = Vec::new();
    b.assemble(/* start address */ 0x8000, /* ROM bank size */ 0x4000, &mut prg_rom)
        .expect("Failed to assemble");
    prg_rom
}
```

6502 Assembler Rust EDSL

Defining and calling a function with string labels:

```
b.label("set_cursor_to_tile_coord"); // define a function with a label
b.inst(Txa, ());                     // x component passed in X register
b.inst(Asl(Accumulator), ());   // multiply by 8 (width of tile)
b.inst(Asl(Accumulator), ());
b.inst(Asl(Accumulator), ());
b.inst(Sta(Absolute), Addr(var::cursor::X));
b.inst(Tya, ());                     // y component passed in Y register
...
b.inst(Rts, ());                     // Return from subroutine

...
// call a function
b.inst(Ldx(ZeroPage), var::bit_table_entry::TILE_X);
b.inst(Ldy(ZeroPage), var::bit_table_entry::TILE_Y);
b.inst(Jsr(Absolute), "set_cursor_to_tile_coord");
```

6502 Assembler Rust EDSL

Static data:

```rust
b.label("blink_colour_table");
const BLINK_COLOURS: [u8; 8] = [
    0x20,
    0x20,
    0x10,
    0x10,
    0x00,
    0x00,
    0x10,
    0x10,
];
for c in BLINK_COLOURS {
    b.literal_byte(c);
}
...
b.inst(Tax, ()); // transfer the blink index into X register
b.inst(Ldy(AbsoluteXIndexed), "blink_colour_table"); // read current blink colour
b.write_ppu_address(0x3F11); // write the blink colour to the palette
b.inst(Sty(Absolute), Addr(0x2007));
```

6502 Assembler Rust EDSL

Platform-specific extension:

```rust
trait BlockNes {
    fn init_ppu(&mut self);
    fn write_ppu_address(&mut self, addr: u16);
    fn write_ppu_value(&mut self, value: u8);
    fn set_ppu_nametable_coord(&mut self, col: u8, row: u8);
    fn set_ppu_palette_universal_background(&mut self, value: u8);
    ...
}

impl BlockNes for Block { ... }

fn program(b: &mut Block) {
    b.inst(...);
    ...
}
```

6502 Assembler Rust EDSL

Rust is a macro language!

```rust
// Read 8 consecutive bytes from a little-endian address stored
// at var::bit_table_address::LO into a buffer beginning at
// var::bit_table_entry::START.
b.inst(Ldx(Immediate), 0);
for i in 0..8 {
    b.inst(Lda(XIndexedIndirect), var::bit_table_address::LO);
    b.inst(Sta(ZeroPage), var::bit_table_entry::START + i);
    b.inst(Inc(ZeroPage), var::bit_table_address::LO);
}
```

6502 Assembler Rust EDSL

INC

Operation: M + 1 → M

Addressing mode errors are type errors:

```
b.inst(Inc(AbsoluteYIndexed), 0x0000);
```

```
error[E0277]: the trait bound
`AbsoluteYIndexed: instruction::inc::AddressingMode`
is not satisfied
```

Addressing Mode
Zero Page
Zero Page, X
Absolute
Absolute, X

6502 Assembler Rust EDSL

How addressing mode errors are caught at compile time:

```rust
pub mod inc {
    pub trait AddressingMode: ReadData + WriteData { ... }

    impl AddressingMode for Absolute { ... }
    impl AddressingMode for AbsoluteXIndexed { ... }
    impl AddressingMode for ZeroPage { ... }
    impl AddressingMode for ZeroPageXIndexed { ... }

    pub struct Inst<A: AddressingMode>(pub A);

    pub fn interpret<A: AddressingMode, M: Memory>(
        _: A, cpu: &mut Cpu,
        memory: &mut M,
    ) -> u8 {
        let data = A::read_data(cpu, memory).wrapping_add(1);
        A::write_data(cpu, memory, data);
        cpu.status.set_negative_from_value(data);
        cpu.status.set_zero_from_value(data);
        cpu.pc = cpu.pc.wrapping_add(A::instruction_bytes());
        A::num_cycles()
    }
}
pub use inc::Inst as Inc;
```

INC

Operation: $M + 1 \rightarrow M$

Addressing Mode
Zero Page
Zero Page, X
Absolute
Absolute, X

Addressing Mode Ergonomics

```
// immediate argument (1 byte)
b.inst(Lda(Immediate), 1);

// implied argument
b.inst(Lsr(Accumulator), ());

// address argument via string label
b.inst(Jsr(Absolute), "set_cursor_to_tile_coord");

// address argument literal
b.inst(Bit(Absolute), Addr(0x2002));

// relative offset via label (single byte so destination must be within +/- 127 bytes)
b.inst(Beq, LabelRelativeOffset("end_set_tile_offset"));
```

Addressing Mode Ergonomics

```rust
pub trait ArgOperand {
    type Operand: operand::Trait;
    fn program(self, block: &mut Block);
}

impl ArgOperand for u8 {
    type Operand = operand::Byte;
    fn program(self, block: &mut Block) { ... }
}

impl ArgOperand for () {
    type Operand = operand::None;
    fn program(self, _block: &mut Block) {}
}

impl ArgOperand for &'static str {
    type Operand = operand::Address;
    fn program(self, block: &mut Block) { ... }
}

pub struct Addr(pub Address);
impl ArgOperand for Addr {
    type Operand = operand::Address;
    fn program(self, block: &mut Block) { ... }
}

pub struct LabelRelativeOffset(pub &'static str);
impl ArgOperand for LabelRelativeOffset {
    type Operand = operand::Byte;
    fn program(self, block: &mut Block) { ... }
}
```

Real Example: Reading the controller button states

```
b.label("copy_controller_state_to_zp");
const CONTROLLER_REG: Addr = Addr(0x4016);

// copy the current controller state
b.inst(Lda(ZeroPage), var::controller::CURR);
b.inst(Sta(ZeroPage), var::controller::PREV);

// toggle the controller strobe bit to copy its current value into shift register
b.inst(Lda(Immediate), 1);
b.inst(Sta(Absolute), CONTROLLER_REG); // set controller strobe
b.inst(Sta(ZeroPage), var::controller::CURR); // store a 1 at destination
b.inst(Lsr(Accumulator), ()); // clear accumulator
b.inst(Sta(Absolute), CONTROLLER_REG); // clear controller strobe
                                       // shift each of the 8 bits of controller state from the shift register into address 0
b.label("copy_controller_state_to_zp_loop");
b.inst(Lda(Absolute), CONTROLLER_REG); // load single bit into LBS of acculumator
b.inst(Lsr(Accumulator), ()); // shift bit into carry flag
b.inst(Rol(ZeroPage), var::controller::CURR); // shift carry flag into 0, and MSB of 0 into carry flag

// if that set the carry flag, this was the 8th iteration
b.inst(Bcc, LabelRelativeOffset("copy_controller_state_to_zp_loop"));

b.inst(Lda(ZeroPage), var::controller::PREV);
b.inst(Eor(Immediate), 0xFF);
b.inst(And(ZeroPage), var::controller::CURR);
b.inst(Sta(ZeroPage), var::controller::PRESS_DELTA);

b.inst(Lda(ZeroPage), var::controller::CURR);
b.inst(Eor(Immediate), 0xFF);
b.inst(And(ZeroPage), var::controller::PREV);
b.inst(Sta(ZeroPage), var::controller::RELEASE_DELTA);

b.inst(Rts, ());
```

More NES shenanigans at gridbugs.org/tags/#nes

- Reverse-Engineering NES Tetris to add Hard Drop
- Conway's Game of Life on the NES in Rust
- Zelda Screen Transitions are Undefined Behaviour
- NES Emulator Debugging