Making Open Source Hardware for Retrogaming on Raspberry Pi

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whoami | disclaimer

❌ Gamer
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Agenda

- Designing a retro gamepad as a simple Raspberry Pi HAT
- Open source hardware certification
- Creating a device-tree overlay with fragments for mapping keys and flashing it in an EEPROM
- Turing Raspberry Pi into retro-gaming machine with RetroPie
- Conclusions
Raspberry Pi

- Low cost single board computer developed in the UK by the Raspberry Pi Foundation
- With Broadcom ARM SoC
- Available with size of credit card (85x56mm), even smaller (65x56mm and 65x30mm) or as a industrial compute module
- As of mid 2018 more than 19 million units have been sold worldwide
- Hardware Attached on Top (HAT) specifications
Gamepad

- “A gamepad, joypad, or simply controller is a type of game controller held in two hands, where the fingers (especially thumbs) are used to provide input.” Wikipedia
- Let’s design a low-cost open source hardware gamepad as a Raspberry Pi add-on
KiCAD

- Free & open source EDA software (GPLv3+)
- Cross platform (works on GNU/Linux distributions, MS Windows and Mac OS X)
- Integrated 3D viewer
- Up to 32 copper layers + 14 fixed-purpose technical layers
- Contributions from CERN developers
- Already adopted by the industry
- http://kicad-pcb.org/
Ingredients for a retro gamepad

- 4 tact buttons for movement
- 2 tact buttons for **select** and **start**
- 2 tact buttons for **A** and **B**
- EEPROM connected to the secondary I2C (pins 27 and 28)
- Bonus: several slots for sensors on the first I2C (pins 3 and 5) to make the board useful for home automation while not playing retro games
The Real Hardware
Open Source Hardware

- Design of physical objects that is publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design
- To be really open source hardware the project needs 4 main elements: hardware, software, documentation, branding
Open Source Hardware Certification

**Open Source Hardware Association (OSHWA):**

- Maintains Certified Projects Directory
- Ensures that the definition of “open source hardware” used by a specific project matches the community definition of open source hardware
- Provides an unique ID for certified hardware based on the country code and a number, for example: BG000007
- Provides an unique logo with for the certified ID
Open Source Hardware Certified!

ANAVI PLAY PHAT
ANAVI TECHNOLOGY

OSHWA UID
BG000007

ANAVI Play pHAT is an open source hardware keypad for Raspberry Pi with 3 slots for I2C sensor modules. It can be used for both gaming and home automation.

CERTIFICATION DATE
July 09, 2018

COUNTRY
Bulgaria

https://certification.oshwa.org/bg000007.html
Device Tree

- Specification for a software data structure that describes hardware components
- Allows compiled Linux kernel to support different hardware configurations within a wider architecture family
- The device tree is compiled as an external file from the Linux kernel binary files called **DTB** (Device Tree Blob) from source code in **DTS** (Device Tree Source)
- Device Tree Compiler (DTC) compiles the source into a binary
- For more details:
  - https://www.devicetree.org/
Device Tree Overlay (DTO)

- DTO enables a central DTB (device tree blob) to be overlaid on the device tree
- DTO includes a number of fragments
- With the default bootloader on Raspberry Pi, DTO can be set at config.txt on the FAT partition with device_tree=
- The EEPROM on a Raspberry Pi add-on board, connected to the secondary I2C bus on pins 27 and 28, should include the overlay required to automatically enable the board
- On Raspbian and other GNU/Linux distributions for Raspberry Pi the information in the EEPROM can be seen from user-space at /proc/device-tree/hat/
Mapping Keys in DTS

- Linux key codes as defined in /usr/include/linux/input-event-codes.h

- Compile **DTBO**:
  
dtc -I dts -O dtb -o anavi-play-phat.dtbo anavi-play-phat.dts

- Create settings.txt file for the EEPROM and specify the DTO

- Create binary **.eep** file from the .txt file using **eepmake**

  ./eepmake settings.txt settings.eep anavi-play-phat.dtbo

- DTS for the DTO of Play pHAT:
  https://github.com/AnaviTechnology/hats/blob/anavi/eepromutils/anavi-play-phat.dts
Flashing an EEPROM for a HAT

- Writing to the EEPROM: pin 2 and 3
- Reading from the EEPROM: pin 27 and 28
- Flash the `.eep` file with `eepflash`:
  https://github.com/raspberrypi/hats
Testing with Open Source Games in Raspbian GNU/Linux distribution

- Verify that Raspberry Pi boots with the attached Play pHAT and the information from the EEPROM in user-space is available
- Verify that the keys on Play pHAT are properly set
- Start a simple game included in the Raspbian Desktop image to test Play pHAT for gaming
RetroPie

- GNU/Linux distribution optimized for playing retro games that combines RetroArch and Emulation Station
- Available for Raspberry Pi, Odroid C1/C2 or personal computer (with Debian or Ubuntu)
- Provides emulators for loading ROMs (digital version of game cartridges), no ROMs are included in RetroPie due to copyright issues
- Useful links:
  - https://retropie.org.uk
  - https://retropie.org.uk/docs/
  - https://github.com/RetroPie
  - https://www.mamedev.org/roms/
Further adjustments for emulators

- **The problem:** the gamepad works fine within the menus of RetroPie but fails after launching some games and emulators.

- **The solution:** add a Python script for software emulation of the keys that works will the game emulators.

  ```
sudo apt-get update
sudo apt-get install -y python-pip
sudo pip install evdev
cd ~
git clone https://github.com/AnaviTechnology/anavi-examples.git
  
- **Add the following lines to** `/etc/rc.local`

  ```
sudo python /home/pi/anavi-examples/anavi-play-phat/anavi-play-gamepad.py &
  ```
Conclusions

- Retro gaming on Raspberry Pi is fun and provides an excellent opportunity for learning modern open source technologies like device tree
- RetroPie is an awesome free and open source Linux distribution for playing retro games on Raspberry Pi
- KiCad is high-quality free and open source software for designing hardware
- Certified open source hardware is a fair way to share schematics and knowledge about physical objects to the community
Thank you!

- https://retropie.org.uk/
- https://github.com/AnaviTechnology/anavi-play-phat
- https://www.crowdsupply.com/anavi-technology/anavi-play-phat