How will open source hardware influence our business and education in the future?

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***Abstract*—This paper presents how open source hardware will influence our business and education in the near future. The open source hardware has been playing a key role in business and education. Historically, for example, the vacuum tube radios technology was invented and patented by Dr. Hiroshi Ando. Mr. Konosuke Matsushita (founder of Panasonic) purchased Ando's patents and delivered the technology to the manufactures in 1932 at no charge. Since 1932, every family in Japan has been owning an inexpensive consumer radio set. The vacuum tube radios technology is the first, and only the first open source hardware. Thanks to open source hardware, 3D printers and laser cutters are becoming cheap and available for personal use together with open source software. In this paper, our experience of building a laser engraving machine with less than US$70 is presented where gcode plays an important role. Innovations of open source hardware including Raspberry Pizero($5), CHIP($9), NanoPi-NEO($7.99), GPU, and others will bring us inexpensive artificial intelligent system. In other words, we may lose many of our jobs in the near future because such cheap AI system can put you out of a job. We must dramatically change the contents of education in order to prepare for the future human jobs. We must determine what contents of education will be needed in the future society. We should rethink how we can have a fun time or a good time with shortened working hours from the global viewpoints.**

Keywords—open source hardware, vacuum tube radios, 3D printers, laser engraving machines, artificial intelligence,GPU, gcode

I. INTRODUCTION

Wikipedia states that **Open-source hardware** (OSH), consists of physical artifacts of technology designed and offered by the open design movement [1]. Both free and open-source software (FOSS) as well as open-source hardware is created by this open-source culture movement and applies a like concept to a variety of components [1].

Wikipedia also says that First hardware focused "open source" activities were started around 1997 by Bruce Perens [1]. This paper would like to correct the Wikipedia statement. The vacuum tube radios technology was invented and patented by Dr. Hiroshi Ando. Mr. Konosuke Matsushita (founder of Panasonic) purchased Ando's patents and delivered the technology to the manufactures in Japan in October 1932 at no charge [2]. Since 1932, every family in Japan has been owning an inexpensive consumer radio set. The vacuum tube radios technology is the first, and only the first open source hardware.

Since the advent of hardware description language (HDL), instead of schematics, sharing HDL code has been forming open source hardware where semiconductor intellectual property cores or IP cores have been playing a key role. ARM -based CPU is one of HDL incubated CPUs. However, ARM IP core is a proprietary product of ARM Ltd and not for free. ARM based devices occupies over 70% market share of embedded system [3]. ARM-based CPU market share in 2010: over 95% in smartphone market [4]. Inexpensive ARM-based CPU has brought a series of Raspberry Pi including Pizero ($5) [5], CHIP($9) [6], and NanoPi-NEO ($7.99) [7], and others. In February 2016, the Raspberry Pi Foundation announced that they had sold eight million devices.

From Gartner, iOS and Android have 98.4% of smartphone market share. Both iOS and Android operating systems are based on open source software as shown in Fig.1.

Worldwide Smartphone Sales to End Users by Operating System in 4Q15 (Thousands of Units)

Operating System	4Q15 Units	4Q15 Market Share (%)	4Q14 Units	4Q14 Market Share (%)
Android	325,394.4	80.7	279,057.5	76.0
iOS	71,525.9	17.7	74,831.7	20.4
Windows	4,395.0	1.1	10,424.5	2.8
Blackberry	906.9	0.2	1,733.9	0.5
Others	887.3	0.2	1,286.9	0.4
Total	**403,109.4**	**100.0**	**367,334.4**	**100.0**

Source: Gartner (February 2016)

Fig.1 Open source operating system of smartphone market share:

http://www.macrumors.com/2016/02/18/ios-android-market-share-q4-15-gartner/

Downloading/updating/upgrading Linux operating systems, applications, development tools, device drivers, other software from the internet for free of charge, you can make a small artificial intelligent system with inexpensive open source hardware.

It is understood that ARM-based CPU and open source software play a key role with open source hardware which can build inexpensive artificial intelligent machines. The system of ARM-based CPU and open source software has globally dominated the smartphone market (95%) and the embedded system market (over 70%) as mentioned earlier.

Innovations of open source hardware including Raspberry Pizero($5), CHIP($9), NanoPi-NEO($7.99), and others will bring us inexpensive artificial intelligent system where they are

all based on ARM-CPU. ARM-based CPU will be a heart of IoT devices as shown in Fig. 2.

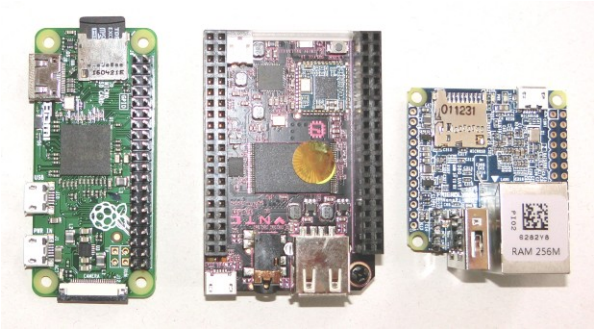

Fig. 2 Pizero, CHIP, NanoPi-NEO from left

Open source software libraries for machine learning include TensorFlow from Google, CrowdFlower, Keras, CNTK from Microsoft, Caffe from UC Berkeley, Deeplearning4j, MXNet, SINGA from Apache, Theano, Chainer, and others. Most of open source machine learning can be programmed by Python. Fig. 3 shows race for AI where many giant companies have been involved in the business competition..

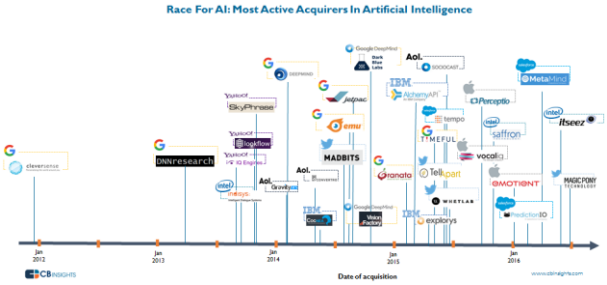

Fig. 3 Race for AI:

https://www.cbinsights.com/blog/top-acquirers-ai-startups-ma-timeline/

We have been using CPUs for long time. However, for machine learning, GPU has been used for fast computation. As shown in Fig. 4, the size of GPU core is much smaller than that of CPU core so that massive GPU cores can be embedded in a single silicon chip.

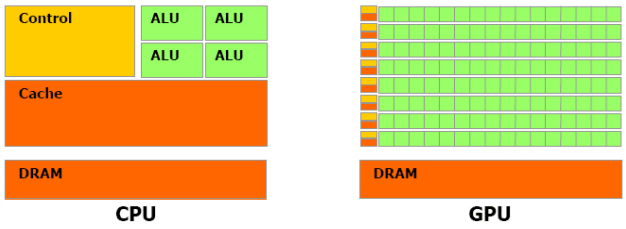

Fig. 4 difference between CPU and GPU

http://allegroviva.com/gpu-computing/difference-between-gpu-and-cpu/

The latest NVIDIA GPU as of Aug. 5 of 2016, Titan X Pascal packs in 3,584 CUDA cores with a 1,417MHz base and 1,531 MHz boost clock in a single chip. The GPU chip is composed of 12 billion transistors with 11 TFLOPS (32bit floating point) capability. It is sold for $1200. The GPU can be used with open source machine learning libraries. Because of the recent progress of GPUs, a student can buy and own a supercomputer by himself/herself.

The GPU computing environment and open source machine learning software will make us to build inexpensive artificial intelligent system. Professor Andre Spicer said that AI could put you out of a job [8]. AI will quickly replace many forms of complex knowledge work ranging from lawyers to librarians, professors to policy analysts [8]. As of Aug. 5 of 2016, the google search result using keywords of AI and "out of a job" is 332,000. Many people believe that AI will be able to improve the efficiency of our jobs or to put you out of a job. In other words, sooner or later, our working hours will be significantly reduced by AI.

We must dramatically change the contents of education in order to prepare for the future human jobs. We must determine what contents of education will be needed in the future society. We should also rethink how we can have a fun time or a good time with shortened working hours from the global viewpoints.

Arduino is another open source platform which uses 8-bit microcontroller of Atmega328 (around $1) and related AVR 8-bit chips. Most of the existing sensors and actuators can be easily controlled by Arduino system where Arduino chip can be connected to GPIO, serial UART, i2c bus interface, spi interface. Arduino will be a heart of IoT devices as like ARM-based CPU.

With the progress of the Drone technology, a variety of MEMS (Micro Electro Mechanical Sensor) sensors have become cheaper for personal smart sensing. Recent two MEMS sensors are distinguished: GY-801 and BME280.

GY-801 is composed of four sensors for Drone: L3G4200D (three-axis gyroscope), ADXL345 (three-axis accelerometer), HMC5883L (three-axis digital compass), and BMP180 (digital pressure sensor). GY-801 module is sold for $8.39.

Fig. 5 GY-801

Fig. 6 BME280

BME280 is composed of three sensors for sensing humidity(± 3%), temperature(± 1°C), and air pressure(± 1hPa). BME-280 module is sold for $4.12.

II. OPEN SOURCE LASER ENGRAVING MACHINE

We have purchased a laser engraving machine kit for $68: http://www.aliexpress.com/item/micro-mini-laser-engraving-machine-diy-kits-laser-CNC-diy-kits/32616470826.html?spm=2114.10010108.1000023.13.Bo7Dzy

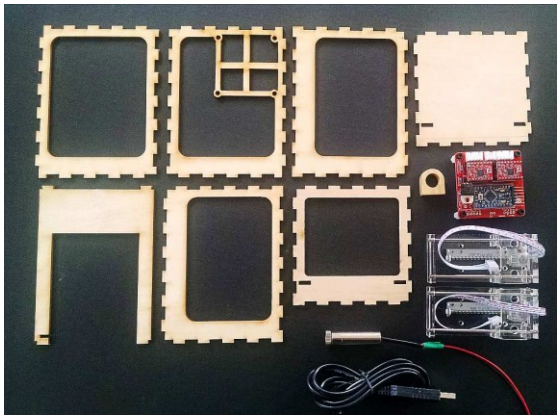

Fig. 7 laser engraving machine kit

The kit is composed of a controller, two slide motors, a laser module where the controller controls motors and the laser without any software. Hacking the kit without manual is not so hard. The followings are described how to hack the kit:

1. Connect the kit to your PC through USB cable.

2. Find the port number (com number) of USB.

3. Use TeraTerm, picocom, or miniterm.py for USB connection between PC and the kit.

4. See the returned messages on the connected screen.

The returned messages include a keyword "GRBL". From "GRBL" we knew that the kit is based on open source laser engraving.

GRBL is a free, open source, high performance software for controlling the motion of machines that move, that make things, or that make things move, and will run on a straight Arduino. Most open source 3D printers have GRBL.

We need three software applications for laser engraving: one is to create a picture: picture editor, the second is to generate GRBL code (gcode) data, the last is to send gcode data to the kit from PC. "gcode" is a keyword for laser engraving/cutting and 3D printing.

The followings are shown how to reach three open source software applications for the purchased kit:

1. Search for "Lite Fire Laser" which is described on the kit web page.

2. We have found the interesting link:

http://cnc-factory.eu/lite-fire-laser-engraver/

3. From the link, we have reached the name of "inkscape" which is an editor of open source engraving software.

4. Search for inkscape plug-in software.

5. We have found the import link for plug-in software:

http://www.jtechphotonics.com/Downloads/JTP_Laser_Tool_V1_6.zip

6. Search for "Lite Fire Laser" for Windows device driver.

7. We have found that CH341 is a device driver.

8. Search for ch341 driver for Windows.

9. Searched result: ch341ser.zip

https://docs.google.com/file/d/0B-mqOQablplXa1c1WVlCOEZTU00/edit?pref=2&pli=1

10. Search for gcode sender

11. Download the gcode sender program:

UniversalGcodeSender.zip

http://bit.ly/1hftIhy

By hacking the kit, three software applications are found to be useful as follows: "inkscape" for picture editor, "JTP_Laser plug-in" inkscape software for generating gcode data, and "universalcodesender.jar" for gcode sender for sending gcode data from PC to the kit.

We have built the laser engraving kit within few hours and have learned a role of "gcode" for manipulating CNC (computer numerical control) machines including 3D printers, laser cutters/engraving machines, PCB fabrication machines, and others.

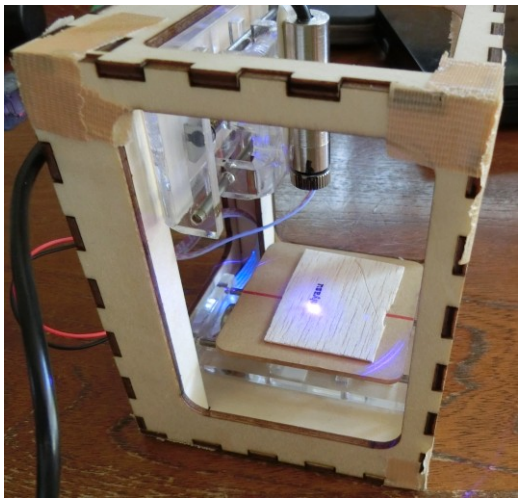

Fig.8 Engraving using the constructed kit

Fig. 8 shows the snapshot of engraving using the constructed kit. The picture was drawn by inkscape editor. The gcode data was generated by inkscape with the plug-in gcode generator. UniversalGcodeSender sent the generated gcode data to the kit. The kit successfully engraved the described picture which was edited by inkscape.

III. CONCLUSIONS

We would like to address that the first open source hardware (vacuum tube radio) was made by Konosuke Matsushita in 1932. The vacuum tube radio satisfies the statement of "open source hardware" described in Wikipedia [1]. From HDL (hardware description language), ARM-based IP cores were created. ARM-based CPU and open source software have dominated the embedded system business (over 70% market share) and smartphone business (over 95% market share).

Open source machine learning libraries make us to build inexpensive artificial intelligent system with open source hardware. GPU plays a key role for fast computation on machine learning. Two kinds of IoT devices are introduced: ARM-based CPU and Arduino.

AI will significantly reduce our working hours or will put you out of a job. We should also determine what contents of education should be needed for the future human jobs. We should also rethink how we can have a fun time or a good time with shortened working hours from the global viewpoints.

REFERENCES.

[1] https://en.wikipedia.org/wiki/Open-source_hardware

[2] http://www.panasonic.com/jp/corporate/history/konosuke-matsushita/051.html

[3] https://community.arm.com/groups/processors/blog/2016/02/23/introducing-cortex-a32-arm-s-smallest-lowest-power-armv8-a-processor-for-next-generation-32-bit-embedded-applications

[4] http://www.theregister.co.uk/2011/02/01/arm_holdings_q4_2010_numbers/

[5] https://www.raspberrypi.org/blog/raspberry-pi-zero/

[6] https://www.kickstarter.com/projects/1598272670/chip-the-worlds-first-9-computer/description

[7] http://www.friendlyarm.com/index.php?route=product/product&product_id=132

[8] http://www.cnbc.com/2016/03/17/man-vs-machine-ai-could-put-you-out-of-a-job.html