Extended LED Tiles: Large and Bi-color Matrix LED Unit with Pattern Drawing Capability

Huu Nguyen Nguyen Tran[1,a)] Mototeru Kawasaki[1,b)] Junichi Akita[1,c)]

Abstract:
The matrix LED can be used for not only displaying but also sensing the incident light by the generated photo current. This fact enables to implement the display and input methods on one matrix LED unit.
The authors have been proposing and developing the block device with dot-matrix LED unit as display device, as well as input device by using visible light, "LED Tile" system, and its applications. In this paper, the two ways of extensions of LED Tile system have been described, extending the display size and extending the number of colors. Their hardware implementations and software library descriptions, as well as the plan of their applications are also described and discussed.

1. Introduction

Block device systems, simple component block device for building large complex systems, have been evolving from the simple structural devices, such as traditional LEGO blocks, to the intelligent devices that have small computer, sensor, actuators, and communication channels. Such intelligent block devices enable to build interactive systems. Each intelligent block device has fixed functions, such as photo sensor, controller, while operations in controller can be externally programmed.

The authors have been proposing and developing the block device with dot-matrix LED unit as display device, as well as input device by using visible light, "LED Tile" system, and its applications[1], [2], [3].

In this paper, the two ways of extensions of LED Tile system have been described, extending the display size and extending the number of colors. Their hardware implementations and software library descriptions, as well as the plan of their applications are also described and discussed.

2. Hardware Configuration

2.1 Principle of Operations

The LED produces the weak electric current by incident light[4], and this fact can be used for light sensing, as well as emitting light for displaying. Here we describe the principle of operation of using dot-matrix LED unit as both display and input device. Here Ri and Cj are the row and column wiring, respectively, which are connected to I/O pins of microcontroller, ash shown in **Fig. 1**. The I/O pins connected to Ri should be configured as analog input terminals as well as output terminals.

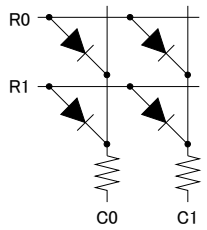

Fig. 1 Principle of operation

(1) Output '0's for all of Ri and Cj (Reset).
(2) C0 as '0', and other Cj and all Ri as inputs.
(3) LEDs connected to C0 are 'integrated'; the incident light generates the photo current which generates the voltage at Ri.
(4) After integration time (approximately 1[ms]), the voltage of all Ri are measured by A/D converters to judge whether each LED is exposed or not by an adequate threshold.
(5) Keep C0 as '0', configure all Ri as output with value of '0' or '1' according to the pattern displayed on this column (Display).
(6) Repeat (1)〜(5) for each columns in order.

As described above, the photo sensing and the displaying are performed in order for all the columns. Note that the input pattern and the display pattern are independent, and the various types of interactions with input pattern and display pattern can be implemented. The time of the integration and the display should be configured so as to realize enough frame rate of displaying, integration time for obtaining voltage difference, and intensity of display.

2.2 Display Size Extension

We first implemented the extension of the LED Tile (LT) device's display size.

[1] Kanazawa University, Kanazawa, 920–1192, Japan
[a)] nguyen@ifdl.jp
[b)] m_kawasaki@ifdl.jp
[c)] akita@is.t.kanazawa-u.ac.jp

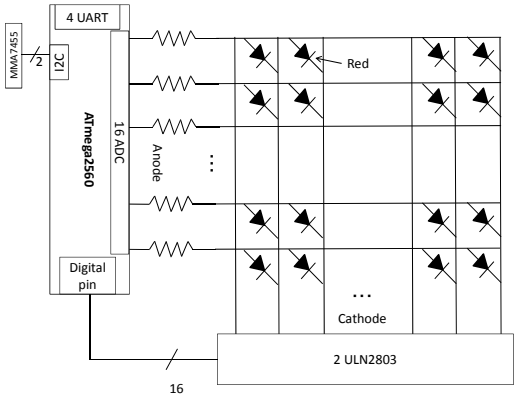

Fig. 2 Overview of extended LED Tile (eLT) device

(a) (b) (c)

Fig. 3 Developed eLT device. (a)front side, (b)front side under LEDs, and (c)back side.

2.2.1 Circuit architecture

Fig. 2 shows the overview of the size-extended LT (eLT) device. The eLT has 16×16 LEDs, with 2×2 dot-matrix LED units, with one microcontroller, ATMEL's ATmega2560, which runs at 16MHz system clock to achieve enough processing power for the increased number of LEDs to be processed.

Four dot-matrix LED units are connected in 2×2, each row and column wires are connected each other. The 16 I/O pins that can be configured as A/D converter inputs are connected to the row terminals of the LEDs. A tri-axis accelerometer (Freescale's MMA7455) is also connected via I2C bus.

Each LED will require approximately 10[mA], this result in the total current of up to 160[mA] for one column I/O pin. The current drive capability of ATmega2560's each I/O pin is not enough to drive up to 16 LEDs in one column. In order to overcome the current drive capability problem, the darlington current driver (Toshiba's ULN2803) is attached to the column's I/O pin.

The eLT device also equips four full-duplex serial communication (UART) channels in four directions for communicating the connected neighbour eLT devices.

2.2.2 Developed device

Fig. 3 shows the developed eLT device. The device size is 76[mm]×76[mm], which fits the mounted 2×2 dot-matrix LED units to achieve gap-less connection with attached neighbour eLTs. The power supply of 5[V] is supplied from outside the device, or the LiPo battery mounted backside of the eLT device.

2.3 Display Color Extension

We next implemented the extension of the LED Tile (LT) device's display color.

2.3.1 Sensitivity for different color

According to the physical principle of LED's photo sensitivity, the LED's photo sensitivity is expected to be maxim at the incident light whose wavelength is identical to that of LED's emitting light. This fact enables to extend the number of the colors of LT device.

Table 1 Measured photo sensitivity for each color LEDs for different light source. (The wavelength of the light sources are shown in the parentheses)

	Red LED	Green LED
Red Laser (650nm)	1.5[V]	0.0[V]
Green Laser (532nm)	1.2[V]	1.7[V]
Red LED (650nm)	1.2[V]	0.0[V]
Green LED (525nm)	1.0[V]	1.5[V]

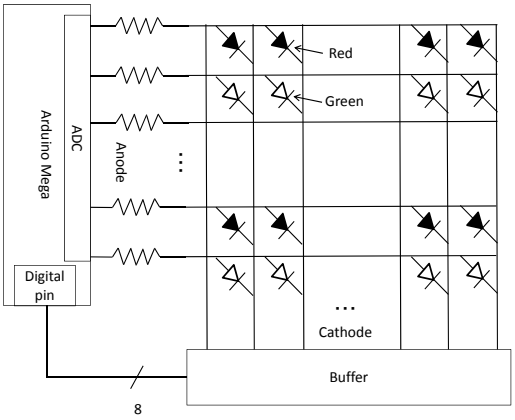

Fig. 4 Circuit configuration of Bi-color LED Tile (bLT) device.

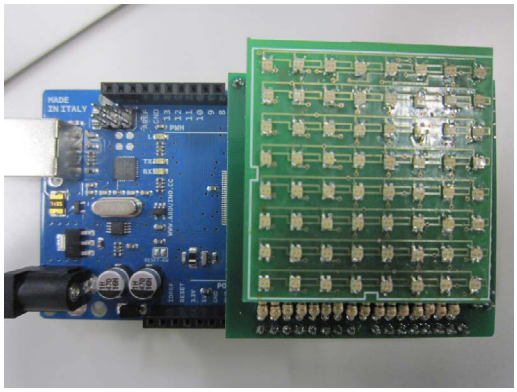

Fig. 5 Developed bi-color dot-matrix LED unit and ArduinoMega controller.

We carried out the preliminary experiment on the photo sensitivity of both red and green LEDs for different color of incident lights. The bi-color chip LED (Stanley's BRBG1211C) is exposed by the light from various light sources, and the voltages of anode terminals of both color LED are measured, as shown in **Table 1**. The red LED is sensivie for both red and green lights, while the green LED is sensitive only for green LED. We can distinguish the color of incident light by measuring the voltages of both color LEDs. Note that the blue LED can also be used as photo sensor, however, since the wavelengths of green and blue are so close that it is difficult to distinguish green and blue color.

2.3.2 Developed device

We developed experimental device to implement bi-color LED Tile (bLT) device with using ArduinoMega board with developed 8×8 bi-color dot-matrix LED unit, as shown in **Fig. 5**. Each LED has common cathode terminal with two separated anode terminal, and the basic principle of operation is identical to that of eLT device. Note that since one column I/O pin has to drive up to 16

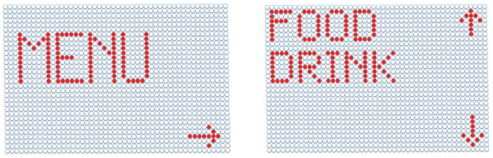

Fig. 6 Example of eLT's application

LEDs (8 red LEDs and 8 green LEDs), darlington current driver (Toshiba's ULN2803) is attached to each column I/O pin.

3. Software libraries

The two types of the developed LT devices, eLT and bLT, have the microcontroller of ATmega2560, and we developed Arduino software libraries for eLT and bLT. The library functions of reading brightness, turning on/off of each LED in dot-matrix display (of each color in bLT device) are implemented. The functions of serial communication and obtaining accelerometer are also implemented for eLT device. The higher level functions, such as recognising the drawn pattern, detecting the attached device, will also be implemented in future.

4. Applications

Here we describe the possible applications of the extended LED Tile devices.

4.1 For Extended Size Device

The advantage of the eLT, large size LED Tile device is the increased number of 'pixels' on one device, in other words, the increased resolution.

Example 1: Definition of the device's function by the drawn pattern – The drawn pattern on eLT device is recognised to define the functions of the eLT device. In the conventional LED Tile device, the low resolution display restricts the variety of the recognisable patterns[3].

Example 2: Menu in the restaurant – Customers can use the light pen to scroll up and down, to change pages; and choose the dishes the menu. After the choices are confirmed, the information will be sent by Xbee to server through the Wi-Fi. In the kitchen, the chef can use computer to make the dishes. (**Fig. 6**)

Example 3: Multiple choice exams – In this application, students can use light pen to tick the right answer in the system. They can scroll up and down; and undo their work. After they have done the exam, the result will be sent to the server by Xbee module. At this time, the teacher can get the final result very quickly.

4.2 For Extended Color Device

The advantage of the bLT, bi-color LED Tile device is the capability of sensing and displaying two colors in each pixel.

Example 1: Two ways of interaction – The separated two ways of interacting with the device are realized, for example, red light for drawing, and green light for scrolling in a drawing tool. It is also possible to implement gesture operation, such as rotating or zooming, by one color light's drawing with pattern recognition. (**Fig. 7**)

Example 2: Extended music box[3] – Red dots for tone, green dots for half tone.

Fig. 7 Application example of bLT device

Example 3: New type games or media arts – For example, red dots and green dots moves horizontally and vertically, respectively, with generating tone when reflected on the edge. It is also possible to implement dot-based game system, such as reversi, with the separated device for each user with wireless communication.

5. Conclusions

In this paper, we describe two variations of extended LED Tile device, the matrix LED block device with pattern drawing capability by visible light; large size one (eLT) and bi-color one (bLT) as well as their software libraries and some idea of their applications. We'll develop the application systems with the developed extended LED Tile devices.

References

[1] J.Akita: Interactive Matrix LED Unit with Functions of Pattern Drawing and Size Extension, IPSJ Journal, 52(2), pp.733–736 (2011).
[2] J.Akita: Matrix LED Unit with Pattern Drawing and Extensive Connection, Proceedings of SIGGRAPH2010, Emerging Technologies (CD-ROM) (2010).
[3] J.Akita: Interactive Block Device System with Pattern Drawing Capability on Matrix LEDs, The ACM SIGCHI Conference on Human Factors in Computing Systems (CHI) 2012, Interactivity (in DVD-ROM) (2012).
[4] S.Hudson: Using Light Emitting Diode Arrays As Touch Sensitive Input And Output Devices, Proc. UIST2004, pp.287-290 (2004).