

---

# CARduino: Device Toolkit Suitable for Use in Automobiles

## **Koji Tsukada**

Future University Hakodate  
116-2, Kamedanakano-cho,  
Hakodate, Hokkaido, Japan  
tsuka@acm.org

## **Maho Oki**

Future University Hakodate  
116-2, Kamedanakano-cho,  
Hakodate, Hokkaido, Japan  
okimaho@acm.org

## **Takafumi Yamamoto**

Future University Hakodate  
116-2, Kamedanakano-cho,  
Hakodate, Hokkaido, Japan  
b1011063@fun.ac.jp

## **Tomohiro Imaizumi**

Future University Hakodate  
116-2, Kamedanakano-cho,  
Hakodate, Hokkaido, Japan  
b1012023@fun.ac.jp

## **Abstract**

Recently, device toolkits like Arduino have become popular. Although many toolkits have been produced, there are only few toolkits focused on the use in particular situation. In this study, we propose a device toolkit, "CARduino", which is suitable for use in automobiles. The CARduino can solve problems (e.g., mess appearance and unstable fixing methods) that are occurred when people use existing toolkits in automobiles. We designed original circuit boards and a housing, and developed the CARduino prototype.

## **Author Keywords**

Device toolkit; automobiles; prototyping;

## **ACM Classification Keywords**

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## **Introduction**

Recently, many research projects have been performed, which focused on interaction techniques in automobiles [4, 5]. In the prototyping phase of such projects, people usually attach various sensors and devices inside a car. However, they often have difficulty to fix these devices to the car interior without spoiling the appearances (Figure 1).

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from [permissions@acm.org](mailto:permissions@acm.org).

*UbiComp/ISWC'15 Adjunct*, September 7-11, 2015, Osaka, Japan.  
Copyright 2015 © ACM 978-1-4503-3575-1/15/09...\$15.00.  
<http://dx.doi.org/10.1145/2800835.2800930>

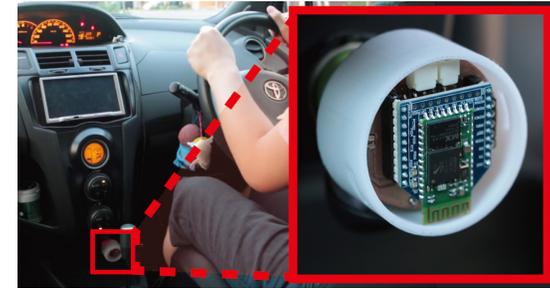
In this research, we focus on solving such problems on the prototyping inside automobiles. We categorized the problems as follows:

- Appearance problem: raw electronic circuits and mess cables disturbs appearances of car interiors.
- Fixing problem: since surfaces of car interiors are curved, people often have difficulty to attach devices on them.
- Sensor problem: sensors should be modularized to support people to attach them on proper positions in consideration of the aims and types of sensors.

To solve these problems, we propose a device toolkit, "CARduino", which is suitable for use in automobiles (Figure 2). Although many device toolkits (e.g., Arduino [1] and Phidgets[3]) have been developed in the last decade, there are few toolkits that focused on the use in certain situation. Lilypad Arduino [2] is an Arduino-compatible toolkit that focused on handcrafts. Our approach focused on the toolkits suited for the prototyping inside automobiles.



**Figure 1:** Problems on the prototyping in automobiles. People often have difficulty to fix devices to the car interior without spoiling the appearances.



**Figure 2:** Appearance of the CARduino prototype.

### **CARduino**

Before developing the CARduino, we considered the design policies in aspects of "fixing method" and "on-board sensors".

#### *Fixing method*

As fixing methods, we selected two candidates, "OBD2" and "cigar lighter socket", in consideration of versatility and power supply. The OBD2 is a connector for a car mechanics to diagnose a car. Although OBD2 provide various data (e.g., speed, temperature, and engine status) of the car, it also has following problems in Japan:

1. The OBD2 protocol is nonpublic and different on the cars sold before 2008.
2. The OBD2 is not supported on the cars sold before early-1990s.
3. The OBD2 port is commonly located under the handle, where is not suited for quick access.

For these reasons, we selected a cigar lighter socket as a fixing method. In this paper, we call it as a “cigar socket” for convenience. The cigar socket usually locates on the center of the dashboard; it also supplies 12V power, which is sufficient for common microcomputers and sensors.

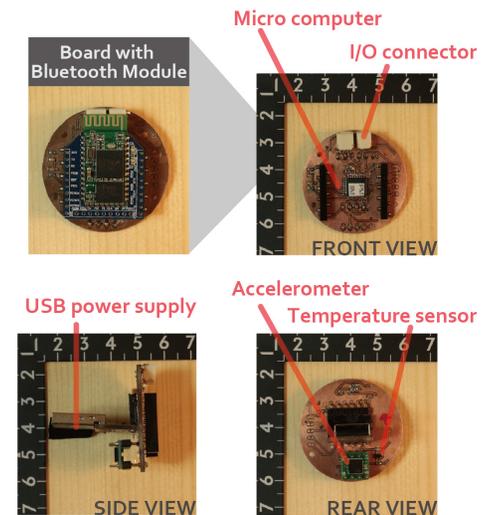
#### *On-board sensors*

Research projects on human-car-interaction typically require various sensors. In such cases, researchers need to consider several aspects of sensors, such as intended purposes and performances. For example, they need different sensors based on the purposes such as “detecting the state of cars/drivers” or “detecting intentional actions of drivers”. Moreover, some sensors (e.g., mics or light sensors) change their functions based on their fixed locations. Therefore, we selected an accelerometer and a temperature sensor as on-board sensors, and attach external I/O connectors for other sensors. The accelerometer attached on the cigar socket can detect various car movements (e.g., moving forward/back, turning left/right and stopping). The temperature sensor attached on a certain location can stably measure temperature inside the car.

#### **Implementation**

Figure 2 and 3 show the appearance of CARduino prototype. The prototype mainly consists of a main board, a power board, and housing. The main board equips sensors, a communication module, and a microcomputer on a circular board (Figure 3). We prepared an accelerometer (KXR94-2050) and a temperature sensor (LM35DZ, TI) as on board sensors, and a Bluetooth module (Bluetooth Bee, Seeed Studio) as a communication module. The Bluetooth module support communication with a host computer or a

smartphone. We selected an AVR microcomputer (ATMega328P-AU, Atmel) to control these devices. The main board also equips external connectors (NHS series, JST) to attach optional I/O devices. The connectors support I<sup>2</sup>C communication, analog inputs, and PWM outputs.



**Figure 3:** The appearances of circuit boards of the prototype.

The power board is designed to be used with a USB-cigar-socket convertor (D106, Daiso) to fix the CARduino on a cigar socket. It mainly consists of a regulator (3.3V/1.5A) and a USB plug. The power board is vertically attached to the main board using the right-angle pin header. Moreover, users can easily update software on the main board just by attaching a USB-serial convertor instead of the power board (Figure 4).



Figure 4: Exchangeable power board. The power board (left) can be replaced by a USB-serial convertor (right) for updating software on the main board.

### Application

In this section, we explain a simple application of the CARduino: interactive car illumination. Car illumination is a popular car customization to archive unique lighting of the car by attaching various lamps inside cars. We think the CARduino is useful to develop interactive car illumination, which changes their own colors/patterns based on the states of the cars/drivers. We attached a full color LED tape (Adafruit) on the car interior and connected to the CARduino through the external connector (Figure 5). The full color LEDs on the tape change their own colors based on the car states detected by on-board sensors (an accelerator and a temperature sensor) of the CARduino. Users also can adjust the mappings of sensors and LED patterns by smartphone apps. For example, users can change the LEDs to red color when the car detects rapid acceleration/deceleration; they can also use it as an attractive speed meter.

### Conclusion

In this paper, we proposed a device toolkit, CARduino, which is suited for use in automobiles. The CARduino equips popular on-board sensors, external connectors for optional devices, and a Bluetooth module to

communicate with smartphones. We will plan to perform workshops using the CARduino, improve the system performance, and explore further applications.



Figure 5: Interactive car illumination using the CARduino

### Acknowledgements

This research was partly supported by CREST, JST.

### References

- [1] Arduino. <http://arduino.cc>.
- [2] Leah Buechley, Mike Eisenberg, Jaime Catchen, and Ali Crockett. The LilyPad Arduino: using computational textiles to investigate engagement, aesthetics, and diversity in computer science education. In *Proceedings of CHI '08*, 423-432.
- [3] Saul Greenberg and Chester Fitchett. Phidgets: easy development of physical interfaces through physical widgets. In *Proceedings of UIST '01*, 209-218.
- [4] Kohei Matsumura and Yasuyuki Sumi. CarCast: a framework for situated in-car conversation sharing. In *Proceedings of AH '14*, Article 17, 4 pages.
- [5] A. Riener, A. Ferscha, P. Frech, M. Hackl, and M. Kaltenberger. Subliminal vibro-tactile based notification of CO2 economy while driving. In *Proceedings of AutomotiveUI '10*, 92-101.