In-vehicle Ecology of Digital Artifacts: an Approach to Sustainable HCI for car

Shengfan He
Indiana University
901 E. 10th Street
Bloomington, IN 47408, USA
he32@indiana.edu

Ying Wang
Beihang University
37 Xueyuan Rd. Haidian, Beijing
10019, China
yingwang@buaa.edu.cn

Abstract
Mobile and ubiquitous computing in the context of car driving is normally designed as a system built in the vehicles for addressing the problem of driver distraction. From a perspective of sustainability and design criticism, we suggest the in-vehicle ecology of digital artifacts as an alternative approach of design for driving context. Through our design practice, we highlight the concept of ecological balance with regard to digital artifacts and explain its implications for approaching sustainable interaction design of in-vehicle infotainment system.

Author Keywords
In-vehicle; design; ecology of artifacts; sustainability

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

Introduction
Mobile and ubiquitous computing together with the ever-advancing wireless Internet have increasingly enabled the use of computational technology in various contexts for various purposes in everyday life. Mobile devices like smartphone are a central element of mobile ubiquity with an ecosystem of mobile applications (APPs) that gives the devices diverse functionality. While as one of the everyday scenarios, car driving context is

particular with regard to embracing mobile devices because of the concern about distracted driving [7,9]. While the demand for information technology in the driving context is obviously observed, such as local search, navigation and communication with others [10].

Against this background, car manufactures have started addressing those information services by embedding the Internet enabled in-vehicle infotainment systems (IVIS) into cars. The built-in IVIS is always specifically designed for driving context so that could cause less driver distraction. The iVoka system of SAIC Roewe 350 enables driver to use information service through voice interaction [4], and BMW featured Head-up Display (HUD) as an option for their 5 and 7 series vehicles for helping driver keep his attention on the road while reading relevant driving information [2]. Actually these functionalities or interactions are also available through mobile APPs (such as Siri and HUDWAY), but the built-in IVIS can provide more driver-friendly way of using them. For example many drivers use voice interaction APPs while driving, but they need pick up the phone and push a push-to-talk (PTT) button to activate the APP; while built-in IVISs with voice interaction always have a PTT button just built in the steering wheel.

However comparing with the built-in IVIS that requires a specific car, the information service offered by mobile devices is much more available, economic and flexible, thus is widely used. People driving used cars can also benefit from information services by means of the APPs in their smartphones. From an ecological perspective, this paper introduces a smartphone based IVIS design, which takes a form of ecology of digital artifacts. Based on the design we highlight the concept of balance in the ecology of digital artifacts, suggesting the necessary of keeping digital artifacts working together to fit in with the context and meanwhile keeping the individuality of each artifact. We also explains its implications for the sustainable approach of interaction design.

Materiality of digital artifacts in the driving context

Motivated by the notion of *digital technology as a material of design*, we regard the mobile devices and the APPs as materials for interaction design of IVIS. From this perspective, we aim at highlighting the potential and value of *existing* digital artifacts for creating new interactive system. As we mentioned above, mobile devices with specific APPs can realize the voice interaction and HUD. Although they are not enough driver-friendly, they still have value as the materials for designing a better system. Apple's Carplay [3] could be regarded as an example of exploiting the existing material of digital artifacts and technology to build up IVIS. Instead of an independent system built into the car, Carplay mirrors the iOS of iPhone to car's interface so it can take advantage of the computational resource and the APP ecosystem of iPhone.

Another concern with regard to materiality in our design and research is the material effect of IVIS. By material effect we refer to an abstract and integrated quality of sustainability, affordability and universality of a digital technology. Jung et al. [5] categorized some factors related to the material effect of digital technology, such as energy consumption, sharability and reconfigurability. Carplay adopts existing operating system as a design material so it to some extent helps reduce the energy consumption, but it still requires specific car models with iOS-enabled interface (such as embedded physical port, color display and a built-in Siri

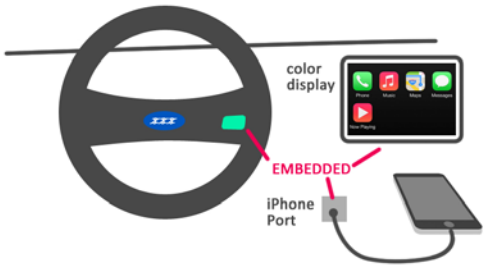

Figure 1. A Carplay enabled IVIS

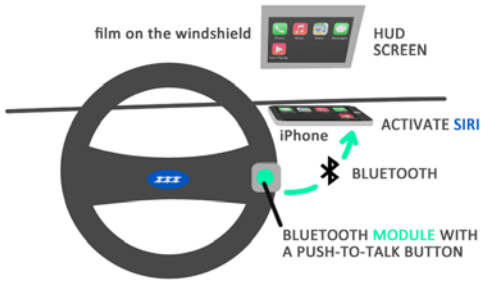

Figure 2. A used car without built-in IVIS

button on the steering wheel). The requirement for the specific hardware can potentially decrease the reconfigurability and sharability of the system, especially the hardware built in a car—such a durable artifact. According to a provider of automotive information and marketing solution named R. L. Polk & Company [1], the average age of car in United State has hit the record of 11.4 years, which is quite a long period for digital technology. Considering the incompatibility between the life span of car and the speed of digital technology innovation, it's advisable to decrease the *interdependency* between IVIS and vehicle, also decrease the material effect of IVIS.

By taking more advantage of existing digital materials (mobile devices and software) in the driving context, we designed a smartphone based IVIS that enables driver to use information services in a more distraction-free approach. The design utilizes voice interaction platform in the smartphone, and a Bluetooth module with PTT button and Mic-phone is *banded on* rather than embedded into the steering wheel for activating the voice interaction. And instead of a specific screen, the design utilizes a semi-transparent film to reflect the smartphone's screen under the windshield as HUD interface. Driver just need to push the PTT button on the steering wheel to manipulate the IVIS via voice interaction, he can also read visual feedbacks from the HUD besides listen to the voice feedbacks. This IVIS design has no dependence on certain vehicle, with the mobile devices everyone can use it no matter what car he is driving. The material effect of this IVIS design is minimized not only because it reduces energy consumption by exploiting existing digital materials, but also because it does not require anything embedded in the vehicle that would bring huge extra material effect.

Ecology of digital artifacts: balance and sustainability

Besides materiality, the IVIS design described above also presents the ecological aspect of digital artifacts, which is about the relationship between different digital artifacts and their context of use. As the functionality of mobile devices is increasingly diversified, the investigation of mobile and ubiquitous computing should always consider it's interconnection with environment and other artifacts as an ecosystem [6]. In this design, the smartphone, the APPs installed in it, the screen, the Bluetooth module and the vehicle together build the ecosystem. Every artifact contributes its strength and cooperates with each other for the integral functionality of the IVIS, but meanwhile they still keep their independency as an individual artifact. This is very similar to the ecological balance that we advocate for the natural (biological) world: creatures living together but not one creature prevailing over another. As a metaphor from the natural world, the ecology with regard to digital artifacts should also take on the feature of balance.

The ecology of artifacts is formed by recognizing the interaction between one artifacts with another. Krippendorff [8] described three kinds of interactions within any ecology: cooperative, competitive and independent. An ecology in a status of balance requires the synergy of these three kinds of interactions. By referring the notion of balance in the ecology of digital artifact, we intend to emphasize that the relationship between different artifacts is neither interdependent nor isolated, but an equilibrium of cooperation and independency. The Figure 3 presents the concept of balance analogically. Taking the IVIS design as an example, the built-in IVIS could be classified as the (iii),

which presents one artifact merging with other artifacts; and directly using mobile devices could be regarded as the (i), in which the relationship between artifacts is quite weak; and the (ii) presents an ecological balance among the digital artifacts, they work together like one unit but every artifact still keeps its individuality. From the example of IVIS, the implications of ecological balance within an ecology of digital artifacts could be recognized: design should on one hand make sure the artifacts fit in with the context and cooperate well with other artifacts; and on the other hand should limit the interdependency between different artifacts so that keep the modularity and reconfigurability of the system, which is significant for the sustainability of the whole interactive system.

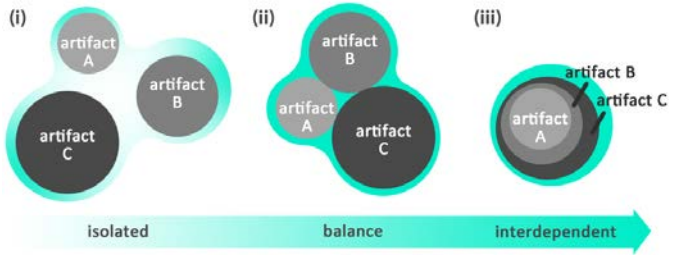

Figure 3. Ecological balance of the digital artifacts

Conclusion

Attempting to enhance the context awareness of mobile and ubiquitous computing, we also need consider the interactions between different mobile devices, because the diversified functionality has increasingly enabled these digital artifacts to be potential material for new interactive system design. Through an IVIS design with mobile devices as design materials, we introduce the concept of ecological balance to suggest that the design with the ecology of digital artifacts is an approach of ubiquitous computing in the driving context, and also an approach to sustainable interaction design.

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