

# Semantic Mapping of Augmented Toys between the Physical and Virtual World

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## ABSTRACT

Based on an augmented toy environment we present an approach of a semantic mapping between the physical and the virtual world. The virtual representation, function and role of play objects (i.e., toys) are determined mainly by their physical appearance, i.e., the role the user would intuitively associate with a specific toy given its physical form. We describe several examples that utilize this inherent semantic mapping to increase entertainment and education (“edutainment”) capabilities of our environment and further discuss the potential and possible implications of this approach.

## Author Keywords

Augmented Toys, Tangible User Interface, Semantic Mapping, Role by Appearance, Mixed Reality.

## ACM Classification Keywords

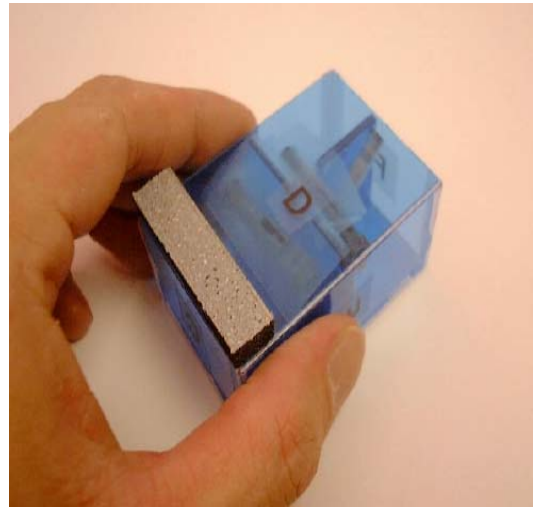
H.5.1 Multimedia Information Systems: *Artificial, augmented, and virtual realities*; H.5.2 User Interfaces: *Theory and methods*; H.5.2 User Interfaces: *Haptic I/O*.

## INTRODUCTION

Tangible User Interfaces (TUI) “augment the real physical world by coupling digital information to everyday physical objects and environments” and taking “advantage of natural physical affordances to achieve a heightened legibility and seamlessness of interaction between people and information” [1].

They are physical artifacts that are supposed to be representation and control for computational media [2]. While TUIs almost always act as control devices, they often lack representational forms that intuitively hint at the exact purpose or usage of this interface (e.g., [3], see Fig. 1). This

is not limited to computational media only, but does in fact apply to many interfaces of our daily lives: they are poorly designed and the role or function of the interface is not linked to its physical form [4].



**Figure 1: The ToolStone [3]. Although the cube supports several intricate forms of interaction, it is not obvious by its physical appearance how it is to be used.**

Thus, we consider a *semantic mapping* between the (virtual) role or function of an object and its appearance (i.e., the representation) to be essential for a better and more intuitive usage of an interface (and thus, a higher usability). This can be achieved by selecting or creating physical objects that unambiguously and obviously display their function or role, thus maximizing the space-multiplex properties (i.e., taking advantage of shape and size) of the environment the objects are integrated in [5].

We realized this idea by creating the Augmented Knight’s Castle [6]. We equipped traditional toys with Pervasive Computing technologies, turning them into smart toys [7] of an augmented toy environment with two goals: to enhance the entertainment experience for children playing with this play set, and to furthermore develop a learning environment.

### SEMANTIC MAPPING OF AUGMENTED TOYS

Since “successful TUIs [...] contain successful physical / digital mappings“ [8], one of the key concepts of our approach is to map the physical to the virtual world by selecting and designing the play objects that have the same semantics in both worlds (cf. Tables 1 and 2).

The role or function of each play object is inherently determined by its physical appearance. This semantic mapping empowers the user to easily understand the role or function of a play object, and therefore allows the fast and intuitive usage of this object as a consequence. In addition to that, the user can focus on *what* (s)he wants to do instead of *how*, since this mapping is totally independent of the underlying technologies.

Using the semantic mapping we can furthermore define relationships between groups of play objects (e.g., the Dragon Knights are the enemies of the King’s Knights, resulting in corresponding action if in close proximity to each other; see below). Again, this mapping is mainly based on the physical appearance and the rather obvious roles of the toys in the play.



Figure 2: Troubadour (left) and Smith (right)

### AUGMENTED KNIGHT’S CASTLE AND SMART TOYS

The described concept of semantic mapping is an integral part of our Augmented Knight’s Castle. We equipped the Playmobil Knight’s Castle with RFID technology to enable the unambiguously and unobtrusively identifying and tracking of tagged play figures. Additionally integrated smart toys allow even more forms of interaction with the play set, for example, the bottle of magic potion, which is equipped with a mobile RFID reader and acceleration sensors (see Fig. 3).

The Augmented Knight’s Castle enhances the entertainment experience by playing sound effects and background music based on the current gameplay. Also utilizing the location-awareness of the play set and the semantic mapping of the play objects, the educational part of the environment allows the children to learn more about the Middle Ages in a playful way. Moreover, the play set can be enabled to teach foreign languages, as well as medieval poems and songs.

Object / play figure (representation)	Role / function
Alchemist	An expert of chemistry and physics who furthermore informs about the history and role of natural science in the Middle Ages.
Smith (cf. Fig. 2)	A craftsman who knows about the manufacturing of weapons and other things made of steel.
Troubadour (cf. Fig. 2)	As a musician, he is responsible for singing and teaching medieval songs and poems.

Table 1: Examples for defining the roles and functions of the toys based on their physical appearance.

The meaning of the play object does not necessarily have to derive from the physical appearance of the figure itself, but can also be linked to other significant and obvious characteristics such as clothes, tools or other things. In Fig. 1, for example, the semantic association is mainly based on the medieval dress style and the tools used by each object.

Object / smart toy (representation)	Role / function
Bottle of Magic Potion (cf. Fig. 3)	It holds a magic potion that can be delivered to figures (e.g., to revive them).
Magic Book	A source of knowledge that is used to inform about all objects and the environment (=world) in general.
Sword (cf. Fig. 3)	This symbol of fight is used to engage in battle with other players, but also to point at things.

Table 2: Smart toys realizing the semantic mapping between the representational form and the (virtual) role / function.



**Figure 3: The bottle is used to deliver a magic potion to an “injured” or “fallen” game figure to “revive” it (left). Before the potion can be delivered to a figure, it must be shaken. The sword is used for selecting figures for a fight with another figure (right). Both objects realize the TouchMe paradigm [9].**

## CONCLUSIONS

We argue for the importance of semantic mapping between the role / function of objects and their physical appearance when employing these objects as TUIs. The presented smart toys are good examples of conceivable semantic mappings: the intuitive usage of these play objects and their integration into the augmented toy environment results in improved and enhanced entertainment and education experiences for the children playing with this play set.

We conclude that during the design process it actually does not matter whether form follows function or vice-versa (e.g., whether you pick a figure and assign a role to it or decide on a role first and select a corresponding figure accordingly), as long as the semantic mapping is intuitive, obvious, and comprehensible. As pointed out before, the semantic distinction may not rely on the appearance of the figure itself but can also be established by metonymic association of other apparent characteristics such as tools or weapons. A combination of both might yield the best result.

Although we believe that our presented examples are well and intuitively chosen and the pre-determination of roles does not constrain the children’s fantasy, it is apparent that these semantic mappings very much depend on the given educational and, even more importantly, on the cultural background: in other countries with different cultures and / or political and religious situations, such a mapping might not be feasible or even obscene.

Therefore, in the context of this specific toy environment, we would like to investigate these issues further in order to find common, intercultural properties as well as differences that might severely influence the selection of forms and functions (e.g., by comparing histories, views, etc. of different countries / peoples).

We are currently planning an extensive user study to evaluate several aspects concerning smart toys and augmented play objects. One of the major points will be the investigation and validation of our claims. To this end, we

will have groups of children of different ages playing with our toy environment. Observing how children use the play objects and interviewing the children afterwards should provide us with valuable insights on how well chosen the toys are and disclose whether our aforementioned claims are really justified.

We moreover intend to abstract from this particular smart environment and try to apply the lessons learned to other environments, such as smart living rooms.

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