

# Intelligent Painting Based on Social Internet of Things

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**Abstract.** Because of social computing, people are more interconnected to things and vice versa. Social computing transforms the Internet of Things to a new form called “Social Internet of Things”. The social Internet of Things needs a social approach to the Internet of Things. It is equally true that design in the context of social computing also requires a social approach to the Internet of Things. A human-object mixed social interaction model or a social approach is demonstrated in this paper and based on which a children-centered social thing, specifically an intelligent painting device is shown in this paper, whose objective is to create a superpower interaction for children and mix the human-human social network with object-object machine network to form a social network consisting of humans and objects and emotions, which focuses more on machine emotion, children behavior and children emotion.

**Keywords:** Social computing · Internet of Things · Social approach · Social interaction · Emotion

## 1 Introduction

Social computing is a cross-disciplinary research and application field with theoretical underpinnings including both computational and social sciences [1]. In the context of Internet of Things where things are connected to each other due to ICT development and with the arrival of social computing, whose unique feature is that it pays more attention to social intelligence rather than social information processing and it holds that technology development shall serve for society and appropriate social knowledge and theories shall be incorporated into technology development, a new form of Internet of Things comes into being and is named “Social Internet of Things”. Social Internet of Things focuses more on machines and objects’ social behaviors on the basis of objects being interconnected. Social computing and social Internet of Things provide designers a research area called social things, which owns certain social approach to the Internet of Things, addresses technological and social aspects of the Internet of Things [2]. The design research area “social things” brings new challenges in designing social smart products that are not only smart and networked but also social, playing a role in human social network to create a two-way social interaction between objects’ network and human’s social network.

The purpose of this paper is to design and implement an intelligent painting product intended for children in the design research area of social things. The social things and social Internet of Things are necessarily a guide for this children-centered product design and additionally how significant the role that color plays in children growing process basically explains why the painting products gain popularity among children. The study finds that people have color perception from the infancy and by the impact of color environment, color can not only stimulate children's visual nerve, but also are related to the development of children's intelligence, emotional stability, personality formation. Color magically affects people's mental state. The color of children's living environment has a great relationship with children's intellectual development, and personality development.

## 2 Related Work

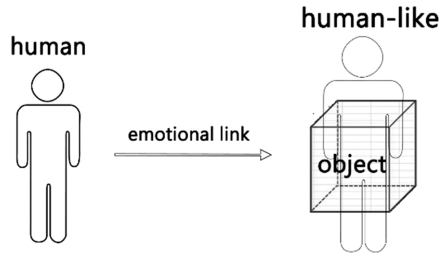
The related literature proposes basic concepts and do some research in regard to Internet of Things, social computing, social Internet of Things, social things. The Internet embodies a great many objects that provide services and information to people. Billions of objects are expected to take a major active role in the future network, bringing physical world data into the world of digital content and services, which results a networking paradigm, called the Internet of Things [3]. Social computing whose definition is that Computational facilitation of social studies and human social dynamics as well as the design and use of ICT technologies that consider social context helps to form the social Internet of Things (SIoT). SIoT has a development process. A first idea of socialization between objects has been introduced by Holmquist et al. whose focus was on solutions that enable smart wireless devices, mostly wireless sensors, to establish temporary relationships [4]. The concept of Embodied Microblogging (EM) also challenges the current vision of IoTs. It proposes that the augmented everyday objects will play the role in mediating the human-to-human communication and supporting additional ways for making noticeable and noticing activities in everyday life [5]. Objects are able to participate in conversations that were previously reserved to humans only [6]. Later there is a view that if things are involved into human's network, the social networks can be built based on the Internet of Things [7]. An individual can share the services offered by smart objects with friends or their things and human's social network is utilized by things as an infrastructure for service discovery and access [8]. The integration between the IoT and the social networks is investigated and a few interesting exemplary applications are described [9]. The exploitation of social networks in the context of the IoT has been investigated to propose to exploit human social network relationships to share the resources offered by a given smart thing [8]. Recently the name Social Internet of Things began to appear in the published papers. This happens in form of interesting attempts to explore the social potentialities of the Internet of Things building blocks [10]. The Social Internet of Things (SIoT) is characterized as an IoT where things are fit for building social associations with different items [11].

Then the design research area on social computing which addresses both technological and social aspect namely “social things” is analyzed [2]. In this paper, the author describes some areas and applications that social things is applied. For example, social things are capable of facilitating the learning to make learning a more effective and more enjoyable social experience. Combined with the application area of social computing [1], entertainment software, which focuses on building intelligent entities (programs, agents, or robots) that can interact with human users. The idea of intelligent painting device based on models of social things that are expatiated in the next part is shaped into and taking account of children psychology which is analyzed [12] and color meaning for children which is analyzed [13], the proposed painting device is children-centered to facilitate education and communication.

### **3 Model of Social Thing**

#### **3.1 Social Thing Model I**

When humans play with objects or machines, usually machines act in two ways, one is machine-like and the other is human-like. The machine-like way shows that the objects or machines really behave like themselves, in other words, they are just machines or objects. In the case of machine-like behavior, people find it hard to interact with the objects responding to humans by just obeying the orders and doing what humans know what they are going to do, which is not surprising at all. Nevertheless, the human-like way gives objects or machines human characteristics including human behavior, human emotion and human personality. Thanks to these features, objects behave like humans and that makes it natural and easy for humans to interact with objects. Objects with emotion tend to attract human’s attention and encourages humans to have a further conversation with objects out of curiosity, which promotes an emotional social interaction between humans and objects. Playing with objects seems not that dull, but more like talking to objects and it creates an entrance for objects to enter human’s social network, for in human’s social network, humans talk to each other, exchange feelings with each other. Now that objects are capable of communicating with humans in a mental state. Thus, it is possible for objects to show some kind of emotion of personality to human, for example being naughty, lazy, rebel, passionate, shy, cold, aggressive, and friendly. Therefore, it is easier that objects become a certain member of human social network in which people regard object as a pal, a friend, a child or even a teacher, not the objects or machines lacking emotion. What mentioned above about objects with emotion and what influence they have on human social network offer a kind of social approach to the Internet of Things. This model is shown in Fig. 1.



**Fig. 1.** Social thing model I

### 3.2 Social Thing Model II

The Internet of Things creates an environment where objects are able to exchange information with each other with the help of sensors and actuators. One object sends an order or message and the other receives the order or message, and gives a feedback. The messages and orders the objects send and receive, together with the feedbacks the objects give are merely mechanical ones including sensor data, wireless data, network data and so on. It is a rigorous technical environment where objects are communicating, talking, sharing only by rigorous code and data. Appropriate and even precise reply shall be given as long as data sending and data transmission is correctly executed. Though objects seem to be talking to each other but still it is a non-emotion way of communicating.

For human's world, the social network comes into being when people have a partner or a circle of friends to communicate with. The way people communicate is emotion-driven. It is always said that people express emotions. That is to say, by means of saying, feeling in heart can be conveyed to other people. Accordingly, people's talking to people is different from objects' talking to objects and it is a emotional way.

With the advance of Internet and Internet of Things, Web 2.0 services and tools emerge to support effective online communication for social communities. The Internet of Things technology is combined with social networks, which leads to the formation of one aspect of social Internet of Things using objects as a communicating medium and has the purpose of social entertainment and social interaction. That offers an inspiration that if there is a link line drawn between certain object and certain human based on the model 1 which suggests that objects with emotion is more likely to interact with humans. The non-emotion machine communication network will be incorporated into human's social emotional communication network. In this situation, feelings of human are not only transmitted in human social network, but also exchanged between two mechanical objects and data are even flown back to human. Consequently, machine's and human's networks have a mixture. Information, specifically, emotional information is on the move in this mixed network. The data transmission becomes emotional thanks to that emotional link connecting humans to machines. These mentioned above is shown in Fig. 2.

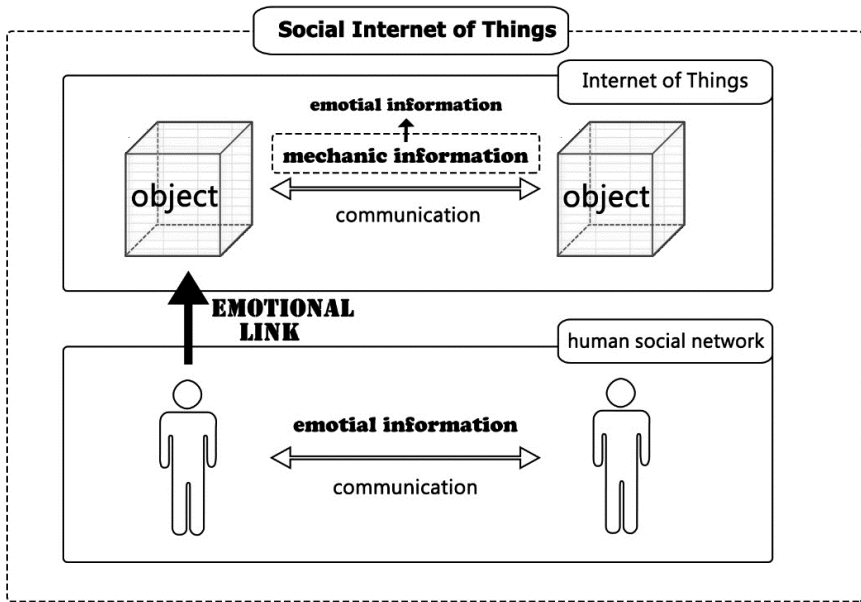


Fig. 2. Social thing model II

### 3.3 Social Thing Model III

In the network of objects and machines, there is an asymmetric relation among objects. For example, Bluetooth, ZigBee, 6LoWPAN networks of sensors/actuators and RFID identification systems are typically asymmetric because there is always a master machine and several slave machines. The master machines send messages to their own slave machines and all slave machines can receive the master orders and it is called broadcasting. Even if this situation looks like human behavior and human relationship existing between a human employer and human employees, it is still an analogy. Basically, it is still a mechanical communicating way that excludes emotion. However, provided that there is a connection established between a person and a master machine and the connection is an emotional bond, there emerges a possibility that master-slave machine communicating pattern is added emotion elements. Considering that in human social network, a group of people often work or play together. During this so called "co-" process, people's feeling, thoughts are shared and expressed among a group where there is also human's master-slave communicating pattern which, however, have emotional features and is different from object ones mentioned above. Thanks to the bond connecting people and a certain master object, the feelings can be conveyed from human's world to objects' world, just like social thing model mentioned above based on object-human connection discussed in social thing model I. Further, if there are more links between a person and a master object, the coordination between human social network and master-slave object network will reach a better state in which people find it more convenient and interesting to co-play, co-work and take advantage of social

objects to more directly express their emotions for social objects which at that time act emotional mediums that are very easy to be noticed when lying in front of people. As a result, feeling runs to master object, and object sends a emotional message to all slave objects which receives the emotional message and shows them. Spontaneously the emotional links between master objects and slave objects are created and even there will be emotional lines appearing between two objects which didn't have any communication before. The social thing model III is shown in Fig. 3.

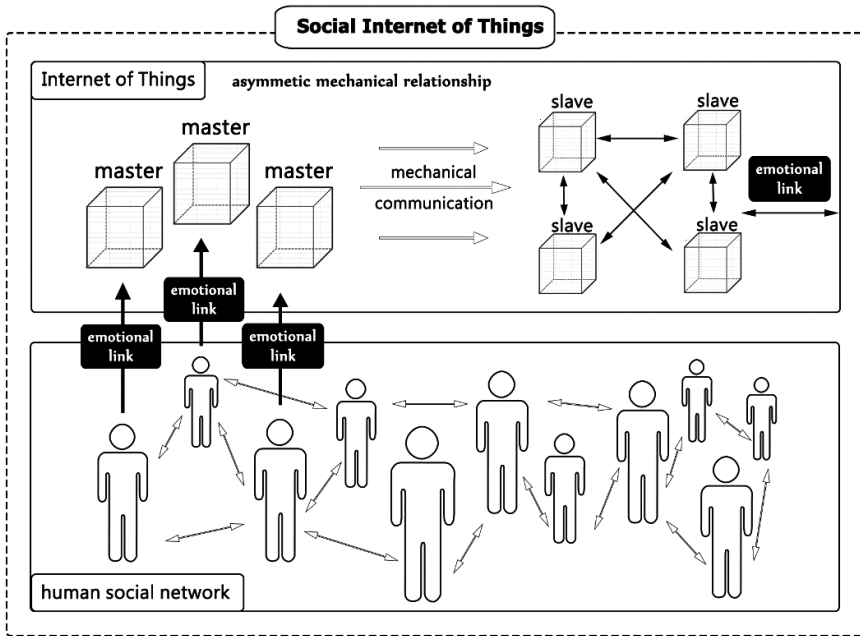


Fig. 3. Social thing model III

## 4 Case Study

To prove the practical function of three social thing models mentioned in Model part and to develop a children-centered, superpower-way and intelligent painting device, this paper elaborates the making process of an intelligent painting device.

The first step is survey, what is discussed above about the significance color has for children growth lays a foundation for the popularity of color products including education-oriented color books and color toy and color painting products. By investigating current color painting products, we notice that there are some defects which are listed as below.

1. consumption of materials is too great,
2. For children, limited cognitive level, not sensitive to color
3. the painting work cannot be preserved permanently

#### 4. parents are not able to participate in the painting creating process in the distance

Apart from the four defects, we also conclude that current painting products lack so called “personality”. In children’s eyes, they are just toys they can play not some human-like things they can communicate with.

What’s more, we notice that the painting process of current painting device can be divided into four sections. Comparing, choosing, imitating and creating. For each section, we will discuss where the super-way interaction inspiration comes from and apply the above social thing models into practice by additionally taking personality lacking into account. Here the latter three sections are chosen to analyze.

For “choosing” section, in consideration of the problem that children have limited cognitive level and are not sensitive to color, we develop a “superpower” way to pick color by making use of color sensor to pick color from real world. For example, you can pick “red” from a red apple and “green” from a green leaf. For children, picking color from real world seems that they have superpower that enables them to be the owner of the real color world. It is a part of “superpower” interaction.

For “imitating” section, We first analyze the children’s behavior and psychology: imitating figures action in fairy tale, and animation; hoping to apply their favorite color in their works and wanting items to have their own exclusive features, based on which we abandon the traditional third-party painting physical media, such as paint, brushes, and fine sand to establish natural user interface of finger grasping movements. The natural finger grasping movements let children feel that they have a superpower that they really catch color in their hands. It is also a part of “superpower” interaction.

For “creating” section, this is the section that we apply the above social thing model into practice. We design two versions of our painting product and each version of product has its own superpower interaction and own mode to connect with object network with human network. For the first version, when children catch color in their hands, they can touch then release to let color “runs” to the target object or target planar. The pattern that color runs to the object has “superpower” interaction features. For the second version, children pick color then open one hand to shoot a color light to light a object with picked color, which is like ironman’s manipulator and that also seems to give children a superpower ability of lighting an object.

The second version designs and develops some functions including saving painting object (painting scheme actually), sharing painting object with friends and parents to make objects more interconnected to human. For two versions of our product, picking color and lighting objects with picked color, which technically, is a one-to-many, object-to-object communication between color sensor and LED lights. The object-to-object communication doesn’t come to end because Internet enables colored objects to share themselves then painting scheme can be saved in the cloud. The saved painting objects/schemes can be shown in children’s different terminals in order to let children see some dimensional color painting effects on terminals and form a human-to-object communication mode.

Besides, the function saving in the second version is saving some copies of painting objects in the cloud like in real life you have pasted some color material stored and take out when deciding to continue the painting process. This saving function transforms former single Internet of Things to object-human communication mode. Children

communicate with their own products. Moreover, the function sharing in the second version provides children with two modes. One is a parent-child communication mode and the other is friend sharing mode. In parent-child communication mode, the color painted through object-to-object mode can be simultaneously displayed for parents on mobile and PC terminals and in addition parents are capable of changing color online and thanks to Internet of Things, some parts of the painting product in front of children can turn to corresponding color. It is a process of remote parent-child communication interactive education and a social Internet of Things called “human-object-human” remote parent-child communication using intelligent painting toy and Internet as media, which is a typical instance of social thing model II especially in one scenario when children collect different colors outside and back home to show colors to their parents, or the other scenario when children pick color and light different colors to express their inner feeling in a color way with their parents.

As for the other sharing mode, friend sharing mode, it is referred to previously that painting objects are able to saved in the cloud and are accessible by other children. Shared painting objects can be downloaded for children to appreciate the idea or experience thoughts and emotions that are hidden in the shared painting objects.

Two scenarios in parent-child communication mode, friend sharing mode and remote parent-child communication as well, typically creates a line between a emotional child with a non-emotional painting object thus to have a mixture of object network and human network where emotions are on the move in this mixed circle, which perfectly stands for the meaning of social thing Model II.

Both versions of our painting products allow many children to paint one big painting object together. From a technical aspect, it is a master-slave mechanical mode addressed in Model III. Here by wireless communication technology called NRF, multiple color-picking sensors conduct a object-object Internet of Things communicating mode with one painting device. The color sensors send picked color to that painting object at the same time. From a experience aspect, because there is a obvious link between the master object and a child, so this is a typical instance of Model III. Several kids are painting together, which gives rise to co-playing behavior pattern, extends the object-object Internet of Things to human-human communication and forms a human-object-human social Internet of Things of co-communicating by taking the intelligent painting product as a tool.

To overcome the defects of lacking personality, more specifically, to make the color display of this intelligent painting device more interesting and more resemble human behavior and personality, we refer to social thing model I to design some human-like color display ways that have human personality trait. The examples are shown as follows.

#### Well-behaved way

- It is the most normal situation and the painted one shows the corresponding color in a stable state.

#### Naughty way

- When children paint one object, the neighbor one is lit while the lighted one is not lit.



- The painted one is flashing in a unstable state and with a fast speed
- The painted one doesn't show the right color at the beginning. Maybe several seconds later comes the right shown color

Rebel way

- The painted one shows the complementary color

Lazy way

- The painted one is too lazy to show color, it is flashing in a slow and unstable state, like yawning
- The painted one is only showing color for a while

Passionate way

- When a painted one is lit, its neighbor ones are lit together creating a "spreading" feeling.

Indifferent way

- The painted one is indifferent, sometimes shows color sometimes refuses to show.

Impulse way

- The painted one is breathing to a brighter state

Shy way

- The painted one is breathing to a dimmer state

Moody way

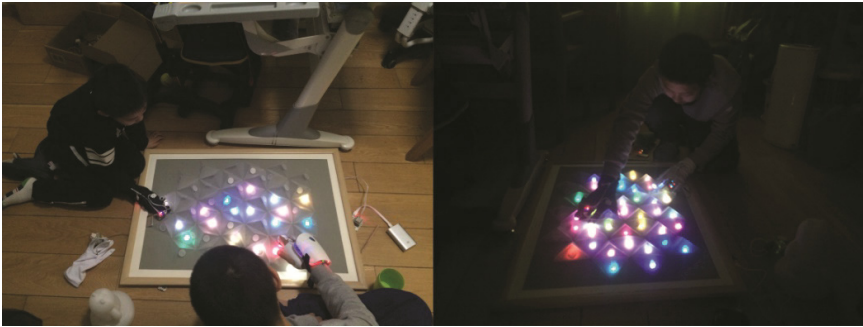
- The painted one changes shown color at irregular intervals

The color display ways described above endows the intelligent painting product human personality and thanks to which it is easier that painting objects become a certain member of children social network in which children regard painting objects as a pal, a friend, a child or even a teacher, not the objects lacking emotion. It perfectly instantiates social thing model I.

## 5 Evaluation and Discussion

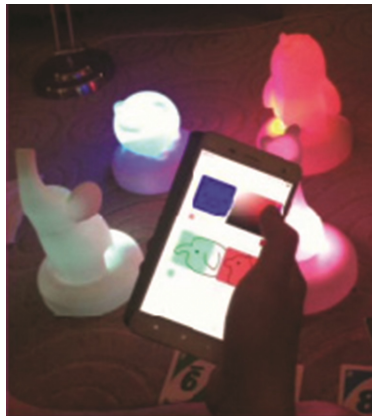
The evaluation part contains two stages. The first stage is that ten children are invited to take part in our intelligent painting product prototype testing. Two testing sections are arranged and one is to let each child experience the emotional color displaying way to see whether the human-like color showing way arrest children's attention or not, which is shown in Fig. 4. Through testing and observing, the conclusion is drawn that some emotion expressing ways really catch children's eyes such as naughty way, lazy way, passionate way, which verify social thing model I. While other human-like ways, for instance, well-behaved way and rebel way confuses the child in a way for during the process of testing, they are more likely to have questions. However, if we give children

extra explanations, we find that children are able to understand but it loses the meaning of human-like way. So here we notice the limitation of some emotional color displaying ways, lacking the knowledge of common human behavior leads to confusion and also for children, imitating human personality only in a visual way is not enough. The other section is that several children play painting product together and as a result, we find that children show great interest for co-painting and our intelligent painting product can increase children engagement. What's more, via observing and coding, we see that when playing the painting product together, it is more natural and common for children to communicate with each other, what they communicate is painting scheme as well as thoughts and feelings, that to some extent verifies the social thing model III.



**Fig. 4.** Emotional color displaying evaluation (Color figure online)

The second stage is that five parent-child groups receive remote parent-child prototype testing, which is shown in Fig. 5. The testing result reveals that children find it more interesting to communicate with their parents and even shy children in daily life is more willing to play this painting with parents. Interview to children is conducted and shows that for children, this painting product is considered as emotional media through which



**Fig. 5.** Parent-child prototype testing

children show their color thinking and inner feeling to their parents, just like a bond. The bond has what social Internet of Things means and can be thought as a verification of Model II.

## 6 Future Work

Considering that there are some limitations to human-like emotional color display. Further research on human behaviors and relationship between human social things and object social things need to be done.

Also, social Internet of Things is yet in its infancy and what now it focuses more on objects' own social network built by themselves without human's intervention. Current intelligent painting device, though, imitates human behavior in some ways but still can only called smart objects rather than social objects. So how to make this intelligent painting product more intelligent so as to become social agents still has a long way to go. Specifically, it is possible for the painting product to be exerted a function of detecting human's emotion and forming their own social networks to form a color emotion world by communicating and cooperation to comfort sad people, to inspire and encourage people at a loss and to really join in human's social network without people's leading.

## References

1. Karjalainen, J., Nyberg, T.R., Mohajeri, B., Gang, X., Zhu, F., Hu, B.: On implementing location-based services in Guangzhou, China. In: Proceedings of 2014 IEEE International Conference on Service Operations and Logistics, and Informatics, Qingdao, pp. 458–463 (2014). doi:[10.1109/SOLI.2014.6960768](https://doi.org/10.1109/SOLI.2014.6960768)
2. Hu, J.: Social things: design research on social computing. In: Rau, P.-L.P. (ed.) CCD 2016. LNCS, vol. 9741, pp. 79–88. Springer, Cham (2016). doi:[10.1007/978-3-319-40093-8\\_9](https://doi.org/10.1007/978-3-319-40093-8_9)
3. Atzori, L., Iera, A., Morabito, G.: From “smart objects” to “social objects”: the next evolutionary step of the internet of things. *IEEE Commun. Mag.* **52**(1), 97–105 (2014). doi:[10.1109/MCOM.2014.6710070](https://doi.org/10.1109/MCOM.2014.6710070)
4. Holmquist, L.E., Mattern, F., Schiele, B., Alahutha, P., Beigl, M., Gallersen, H.: Smart-its friends: a technique for users to easily establish connections between smart artefacts. In: Proceedings of ACM UbiComp 2001, September–October 2001
5. Nazz, E., Sokoler, T.: Walky for embodied microblogging: sharing mundane activities through augmented everyday objects. In: Proceedings of the 13th International Conference on Human–Computer Interaction with Mobile Devices and Services, MobileHCI, September 2011
6. Mendes, P.: Social-driven internet of connected objects. In: Proceedings of the Interconnecting Smart Objects with the Internet Workshop, March 2011
7. Ding, L., Shi, P., Liu, B.: The clustering of internet internet of things and social network. In: Proceedings of the 3rd International Symposium on Knowledge Acquisition and Modeling, October 2010
8. Guinard, D., Fischer, M., Trifa, V.: Sharing using social networks in a composable web of things. In: Proceedings of IEEE Percom 2010, March–April 2010

9. Kranz, M., Roalter, L., Michahelles, F.: Things that twitter: social networks and the internet of things. In: Proceedings of the Pervasive 2010, the Citizen Internet of Things 2010 Workshop CIoT 2010: What Can the Internet of Things Do for the Citizen? May 2010
10. Boucouvalas, A.C., Kosmatos, E.A., Tselikas, N.D.: Integrating RFIDS and smart objects into a unified internet of things architecture. *Adv. Internet Things* **1**, 5–12 (2011)
11. Tripathy, B.K., Dutta, D., Tazivazvino, C.: On the research and development of social internet of things. In: Mavromoustakis, C.X., Mastorakis, G., Batalla, J.M. (eds.) *Internet of Things (IoT) in 5G Mobile Technologies*, pp. 153–173. Springer International Publishing, Cham (2016)
12. Radu, I., MacIntyre, B.: Using children's developmental psychology to guide augmented-reality design and usability. In: 2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp. 227–236. Atlanta, GA (2012). doi:[10.1109/ISMAR.2012.6402561](https://doi.org/10.1109/ISMAR.2012.6402561)
13. Cywocicz, Y.M., Friedman, D., Duff, M.: Pictures and their colors: what do children remember? *J. Cogn. Neurosci.* **15**(5), 759–768 (2003). doi:[10.1162/jocn.2003.15.5.759](https://doi.org/10.1162/jocn.2003.15.5.759)