Augmented Reality in the service of energy conservation

Development of an Augmented Reality system for energy consumption control and management

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ABSTRACT

Energy is currently a valuable and vital resource that characterizes every aspect of our daily lives, powers our homes, our cities, our transportation and is responsible for our resources.

However, our current pattern of energy consumption is still highly dependent on fossil fuels, the use of fossil fuels for energy generation generates CO2 and other greenhouse gases that contribute to global warming and climate change. This already very negative condition has been exacerbated by recent energy crises that have highlighted the need to adopt new forms of energy and achieve a new level of awareness in energy consumption. In this scenario, saving energy and reducing waste is therefore a duty and a necessity for each of us.

The IEA recently published the Electricity 2024, [1] which highlights and summarizes the current state of world electricity consumption and contains forecasts on the evolution of this market from now until the end of 2026. According to the above report, world electricity consumption grew by 2.4 percent in 2023. This trend has not been uniform globally; in fact, the advanced economies, namely the United States and Canada, Japan, South Korea, Australia and New Zealand, have experienced a decline in consumption due to the post-pandemic period recorded in 2022.

The IEA predicts that there will be a significant increase in electricity consumption in the three-year period 2024-26, which is expected to affect all world economies. The annual global increase between now and 2026 is expected to be 3.4 percent. According to IEA forecasts, [1] the most significant increase in electricity consumption expected between now and 2026 will be related to the increasing deployment of new technologies and applications based on the use of artificial intelligence.

All these data show that saving energy is a challenge that requires everyone's commitment, especially in their daily lives, so every action contributes to creating a more liveable world and improving the global energy condition. People should be aware that they can contribute to reducing energy consumption by paying attention to what they do in their daily lives and in their homes to help reduce their impact.

AR technology comes into play in this scenario, making previously invisible factors, such as energy consumption, visible to users. This paper proposes to design and develop an AR system to guide energy management within homes. Its purpose is to control devices and monitor their performance and consumption, thus promoting a mindset toward sustainable energy use.

CCS CONCEPTS

• Human-centered computing • Human computer interaction (HCI) • Interaction paradigms • Mixed/augmented reality

KEYWORDS

Energy consumption, Augmented reality

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1 Energy consumption factors in homes

The residential sector is currently a major contributor to energy consumption and waste, as shown by the IEA (2023), Energy End-uses and Efficiency Indicators. [2]
Consumption in the residential sector is divided into different areas of use including: heating, hot water, cooking, appliances, lighting and unspecified residential.
When analysing the data for Italy, we notice that space heating has the highest energy consumption. We also see a high value for water heating and the use of household appliances. Comparing these values with those for Spain, we see that the most important category of energy consumption is space heating, followed by water heating and cooking. Several factors contribute to the increase in consumption and especially energy waste in homes, some of which are: the type of home, the state and age of appliances and their use.

Considering the data collected by ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development), [3] it can be stated that, even by 2022, the housing sector is more likely to be characterized by poor quality properties

with appliances belonging to the lowest energy classes. Analysing the data [3] shows that the weight of F and G classes is in fact between 20% and 40% of the total for all housing types.

Analysing real estate market trends, a significant difference can be seen between the energy classes of appliances purchased according to the location of the properties.
In fact, if we look at properties located in central areas or closer to the center, the appliances that fall into the best performing energy classes, i.e. A and B, are between 20 and 40 %, whereas in the case of properties located in peripheral areas, around 40 and 70 % of appliances fall into energy classes F and G.

Another determining factor for energy consumption is the condition and age of household appliances and equipment. According to Istat data for Italy [4], 57.8% of Italian households use appliances that are more than 10 years old, while 32.5% use appliances or equipment that are at least 20 years old. Among the various systems, central heating systems are the oldest, in fact more than 40% are at least 20 years old while if we look at the data corresponding to single appliances we notice that only 16.1% are at least 20 years old.

The age of the devices has an impact on energy consumption, as newer devices also lead to greater energy efficiency and less wasted energy. If we look at individual appliances and their age, we see that the washing machine, tumble dryer and dishwasher are among the newest appliances, as they are usually 1 to 4 years old, while for the hob, oven and freezer the percentage of devices with 20 or more years is higher.

1.1 How AR can help users save energy

Augmented Reality comes into play in this scenario, which, through the implementation of various devices in the home, can help the user have greater control over energy consumption.
An example of the application of this technology within the home is room temperature control. In fact, keeping the home at an ideal temperature ensures greater energy efficiency. The recommended temperature in the home is between 18 and 19 degrees; for every degree less, 5 to 10 percent of consumption can be saved.

Another key aspect is the control of household appliances; in fact, according to the data collected, [5] many of them operate in standby mode, drawing power ranging from 1 to 4 watts. If we multiply this by 24 hours, consumption is between 24 and 96 Wh. 'AR can help the user monitor the consumption of each individual appliance, allowing them to identify the most energy-intensive ones and turn them off when they are not needed. In addition, through AR it is possible to control devices remotely, for example by adjusting lighting and temperature. Finally, through intuitive interfaces, the user will be able to view the energy consumption of each room and each individual device in real time, thus understanding how energy is consumed within their home.
In conclusion, the project proposes the development of an AR system to help users effectively visualise and control their energy consumption, proposing specific examples such as home temperature regulation and monitoring of household appliances to minimise unnecessary consumption, reducing waste and contributing to energy conservation.

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