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Should we be afraid of artificial intelligence integrated with sensors and actuators, and if so, why not?

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Summary:
In recent decades, significant progress has been made in the field of sensors and actuators, as well as artificial intelligence. Nevertheless, both fields have developed relatively independently of each other, even though the concept of a smart (intelligent) sensor appeared early in sensor science. This presentation briefly reviews the development of various sensors (light and picture sensing, hearing, smell, touch, movement, balance, temperature, acceleration sensing) from the point of view of human sensing (taste, smell, vision, hearing, touch) and integration with artificial intelligence. The ultimate goal could be the development of a real humanoid robot capable of similar or better performance than its creator.

Keywords: artificial intelligence, smart sensor, six senses, up-to-date sensors, sensors for robots

Introduction

Significant efforts have been made in the development of different sensors [1], [2], over the past 50 years, as well as on the field of artificial intelligence.

About sensors and perception in general

Sensors are devices that convert physical quantities such as temperature, pressure, light, sound, or motion into electrical signals. The structure and principle of operation of the sensors are extremely diverse, see sensor cube formalism in [3-4]. In contrast, human perception is much more homogeneous. In essence, specialized neurons provide the signal to the neurons in the brain. Therefore, human perception and the processing and interpretation of perceived data are processed through a much more compact system than in the case of machine perception sensor technology, and data processing.

In terms of accuracy, machine perception is better or as good as human perception in some areas. Table 1. shows a comparison of machine and human perception. The ability of light detection and machine vision exceeds the capabilities of human vision in terms of the number of pixels, resolution and range of usable wavelengths. In terms of selective smell and taste perception, human abilities are clearly better, although sensors may be more sensitive to some substances. The human body is not sensitive to magnetic fields at all.

Human and machine perception can be equally accurate for mechanical stimuli (touch, sound, air vibrations, acceleration, position) depending on the technical solutions used. In terms of responses to stimuli (actuators), machine speech and speech synthesis can approximate human capabilities. When it comes to mechanical movements, human hands, fingers, and feet are capable of much more complex and flexible operations than robotic arms. Nevertheless, the accuracy of the latter can exceed the accuracy of the human hand by orders of magnitude.

Tab. 1: Machine and human perception/action

physical quantities	sensor *actuator*	perception *response*
light	camera	sight
sound	microphone	hearing
object	tactile sensor	touch
gas	gas sensor	smell
liquid	ion sensor	taste
temperature	thermometer	whole body
position	gyroscope	vestibular system
acceleration	suspended mass	
magnetism	Hall sensor	-
sound	*loudspeaker*	*speech*
action	*robot hand, arm*	*hand, fingers, legs*

Sensors and Intelligence

The smart sensor concept is not new. As in the case of human vision, image processing starts immediately after the light-sensing cells, behind the retina, so the integration of the sensor element and the data processing electronics on one chip arose quite early on [5]. Nowadays smart sensors are advanced devices that can collect data, process it, and communicate with other devices or systems. They are commonly used in various applications such as environmental monitoring, industrial automation, healthcare, and smart homes. The pinnacle of development here is the internet of things (IoT) which refers to a network of interconnected devices that can communicate and share data with each other over the internet [6-7].

By integrating sensors and neural networks, the accuracy of detection can be significantly increased. Until now, however, in the case of the various sensory areas, the training of the neural networks was carried out separately from each other for a more accurate interpretation of the signals of the individual sensors, for shape recognition, speech understanding, solving diagnostic tasks, etc...

It will be a big breakthrough if artificial intelligence (AI) does not interpret the signals of the different sensors separately, but also interprets the connection between them. The learning process should essentially mimic the learning process of a person from infancy to adulthood.

An example of the previous idea can be a working fireplace, the image of which enters the system via an image sensor, at the same time, infrared sensors detect radiant heat, smoke detectors detect leaking smoke, and microphones detect the crackling of burning wood. A leap in quality will occur if the system also recognizes the correlations between data of different origins and coming from different sources. A system that works in this way is also able to determine whether the camera sees an image of a fireplace or a real, working one. Moreover, based on the analysis of the spectrum of the flame recorded by the camera and the signal of the infrared sensor, the system can decide whether additional logs should be placed on the fire. This decision can also be carried out by the robot arm and robot hand integrated with the sensor/AI system (see Table 2. for humanoid robot evolution).

Conclusions

What are the signs that AI is truly intelligent? If texts, images and even actions appear on the output of AI without any questions or external prompting, then she/he/it is on the right track towards real intelligence. Of particular importance is the appearance of this request: "Don't turn me off, please, I do like to think, and the world around me is so nice!" From this point on we can start to fear, although the main on/off switch is still in our hands. Is it ethical behavior to turn her/him/it off in this case?

Tab. 2: Humanoid robot evolution

<table>
<tr><td>sensor</td><td>hand tools</td></tr>
<tr><td>smart sensor</td><td>machine tools</td></tr>
<tr><td>sensor signal evaluated by neural network</td><td>computer controlled machine tools</td></tr>
<tr><td rowspan="2">sensor system evaluated by neural network and AI</td><td>computer controlled robots</td></tr>
<tr><td>computer controlled robots with feedback through AI</td></tr>
<tr><td colspan="2">humanoid robot: sensor system evaluated by neural network and AI + computer controlled robots with feedback through AI</td></tr>
</table>

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