Chapter 10

Cognitive Computing

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Cognitive computing is the use of computational intelligence to assist in the decision-making human nature, characterized by unsupervised learning capabilities and real-time interaction. Based on AI and signal processing, cognitive computing systems cover machine learning, automated inference, natural language processing, speech recognition, and computer vision (object recognition).

10.1 General Features

There is disagreement on the definition of cognitive computing (CC), whether in academia or industry, but in general, the term refers to the hardware or software inspired by the human brain or mind (a trait of natural computation characteristic of computational inteliggence) for supporting human decision-making process. In this sense, CC is especially close to human cognition, being modeled based on human behavior through stimuli there are used by humans as well (e.g., audible and visible spectrum processing). The applications gather data analysis with adaptive user interfaces (AUI) to especialize in contexts [1, 2, 3, 4, 5, 6, 7, 8, 9, 10] and help to improve human decision-making [11, 12, 13, 14, 15].

Some features of CCs:

- Adaptation: online learning with data (e.g., from sensors) and models (goal, requirements), potentially in real-time [16];
- Interactivity: comfort and ease for the user. Can interact with sensors and other devices, services in the cloud, and other people;
- Iterativeness and persistence: can iteratively perform searches when interacting with the user or another system [17];

- Considers context: potentially identify and extract contextual elements such as meaning, syntax, time, location, etc., from linked data, being able to draw on multiple sources of information, including structured and unstructured contents [18].

10.1.1 Cognitive Analytics

CC platforms are typically specialized in big data, i.e., analyzing/mining large amounts of unstructured data. Non-supervised learning is characteristic of CI, allowing text, audio, image, and video documents, often forming data structures elaborate as in social media analysis, to be used without the need of labels. This non-need labeling is pointed out as the main advantage of Cognitive Analytics (CA) over traditional methods of big data [19, 20, 21].

Other CA features include:

- Adaptation: Capability of extract value from different contexts, with minimized human supervision, via computational intelligence [22];

- The interactivity with natural language: Communication through bots [23].

Cognitive analytics can interface with the user through audiovisual analytics for output (input to the user-system), signal processing for input (output to the user-system), and computational intelligence for analysis and decision-making [24, 25, 26].

10.1.2 Complexity

Dealing with real systems usually implies dealing with complex systems, i.e., made up of several parts that, together, present emergent behavior. Complex systems, especially complex networks, tend to have scale-free distributions. There are many other nonlinearities, phase transitions, unintuitive clusterization, fractilities, and chaotic properties in complex systems, whether they are free of scale or not [27, 28, 29].

The theory promoted by the Santa Fe Institute (SFI), which promotes research on this complexity since the decade of 1980, assumes that a complex systems have non-consensual definitions. They are made up of several parts, present emergent behavior, and have a combination of these characteristics: they have adaptive behavior, process information, can reproduce themselves, are integrated into other complex systems, and are integrated into themselves. In this sense, big data meets cognitive computing, and reaches our daily life via IoT to evidence, reinforce, erect, or destroy complex systems [30, 31, 32, 33].

10.2 Natural Computing

The natural computation contributes to CC mainly with bioinspired algorithms capable of learning and predicting. They have a valuation (market, conceptual, academic, and artistic) inherent to transdisciplinarity and deal with concepts such as life and intelligence [34, 35, 36].

10.2.1 Bayesian Inference

The Bayesian Inference (BI) provides baseline informative and competitive results for pattern recognition and CI in general (including natural computation). It means that they are fundamental for reference in the interpretation of CI applied in CC and are used in practice for learning and tasks such as classification and regression in supervised and unsupervised cases. BI is canonical in data analysis (observation of real phenomena) and in subsequent and appropriate decision-making, complementing, monitoring, supporting, and optimizing natural computation [37, 38, 39].

10.3 Personal and Collective Transparency

Personal transparency advocates opening up our sensors (e.g., cell phones) to public access, restraining privacy to specific occasions, not to the standard modus operandi. For example, you can leave the audio, captured by an arbitrary microphone, in streaming 100% of the time for listening via free online WebRadio [40]. It is necessary to identify events of interest given the amount of uninformative data. Event localization is also possible, especially if there are two or more microphones in the same system. These paradigms of personal transparency were suggested for positions of responsibility, such as politicians, and have also found support in civil society to share and document processes, monitor their efforts, work as a team in an asynchronous and geographically distributed way, and prove dedication to academia and industry [41]. Other applications of personal transparency can already be understood as collective transparency: cameras and microphones open and publicly accessible online in public instances, mainly those of greater responsibility. Security is one of the main arguments for personal and collective transparency, as it discourages threats and bullying. It is crucial for such transparencies to allow analysis or even navigation of the big data resulting [42].

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