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Mini Review

Artificial Intelligence Techniques as Potential Tools for Large Scale Surveillance and Interventions for Obesity

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ISSN: 2578-0263

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Submission: February 08, 2020

Published: February 19, 2020

Volume 3 - Issue 4

How to cite this article: Alice Z Guo, Min Jiang. Artificial Intelligence Techniques as Potential Tools for Large Scale Surveillance and Interventions for Obesity. Interventions Obes Diabetes 3(4). IOD.000569.2020.
DOI: 10.31031/IOD.2020.03.000569

Abstract

Obesity and diabetes are two metabolic disorder diseases, which are strictly correlated. The diagnosis and surveillance of obesity is crucial for public health management, policy making, and interventions. Current practices are mainly based on individuals' visits to hospitals or clinics to get the measurement and diagnosis for obesity and diabetes, or with telephone calls and personal interviews for surveillance. We advocate that with advances in artificial intelligence (AI), there is great potential to perform obesity diagnosis and surveillance with AI technologies. The key approaches are based on taking pictures or photos of human faces or bodies by using camera sensors, performing computational analysis of the photos, and obtaining the body mass index (BMI) estimation. These AI technologies make it possible to accomplish a large scale diagnosis and monitoring of public health conditions. Furthermore, these technologies also make it possible for interventions with large populations, aided by Internet connections and smart phones for communications. In this article, the aforementioned idea is presented with a brief overview and summary of the currently available AI technologies, opening a window for an innovative way to perform diagnosis, surveillance, and interventions for obesity.

Keywords: Obesity; Diagnosis; Body mass index; Surveillance; Interventions

Abbreviations: AI: Artificial Intelligence; BMI: Body Mass Index; SVR: Support Vector Regression; GPR: Gaussian Process Regression; CJWR: Cheek-to-Jaw-Width Ratio; WHR: Face Width-to-Height Ratio; PAR: Face Perimeter to Area Ratio

Introduction

According to the Centers for Disease Control and Prevention (CDC), obesity is quite common and poses a serious issue in the United States, with about 39.8% of adults and 18.5% of children and adolescents (aged 2-19 years) who have obesity. The estimated annual medical cost of obesity in the United States was $147 billion USD in 2008; and the medical cost for people who have obesity was $1,429 higher than those of normal weight. Obviously, obesity has already become a serious problem for public health in the states. Nationally, a surveillance system is needed to examine public health issues across several years, track the trends, compare health among groups of people, and determine whether something is improving or worsening for a specific group of people. According to the CDC, the current surveillance system is mainly based on telephone calls and/or personal interviews, which are expensive, labor-intensive, low-efficient, and possibly inaccurate. On the other hand, artificial intelligence (AI) is a very active area and has been raised as one of the national priorities in research and development. On February 11, 2019, President Trump signed Executive Order 13859, announcing the American AI Initiative-The United States' national strategy on artificial intelligence. The Initiative is a government strategy for collaboration and engagement with the private sector, academia, and the public.

Thus, it is highly expected that AI technologies will be developed and applied in various domains. Based on this, we advocate the development and application of AI technologies as great tools potentially for surveillance and interventions in obesity. In this article, we briefly overview some related AI technologies with the objective of drawing the public's attention on the usage of AI technologies for obesity surveillance and interventions.

Artificial Intelligence Techniques Related

In psychology and human perception studies [1-3], it was showed that the human facial features or measures are correlated to human body weight or body mass index (BMI). These studies focus on finding the related, specific measures on faces, and computing the correlations between facial measures and the BMI, using small datasets, e.g. with hundreds of face photos. The BMI values can be classified into four main categories: underweight, normal, overweight, and obese. Motivated by the psychology studies [1-3], Wen and Guo [4] developed the first computational method for visual BMI analysis, i.e. mapping facial features or measures to BMI values, modeled as a regression problem. The key steps of computation include (1) face detection, (2) facial landmark localization, (3) facial geometric feature computation, and (4) regression mapping. Various regression techniques were tested, such as the support vector regression (SVR) and Gaussian process regression (GPR). A relatively large dataset with 14,596 face images, selected from a database called Morph, was used for experimental validation. The BMI estimation can achieve results with mean absolute errors around 3.2. The pioneering work by Wen & Guo [4] has inspired several following research works. For example, Kocabey et al. [5] explored the use of deep learning models, such as the VGG or VGG-face model, for BMI estimation from facial images. Dantcheva et al. [6] applied another deep network, called ResNet with 50 layers, for facial BMI analysis. Barr et al. [7] even applied the facial BMI analysis technology developed in [4] for lifestyle intervention. They used the already-learned model [4] on a different population with only young adults for BMI estimation. The approach does not take any new data (e.g. samples from the new population captured in a different environment) to tune the model [4] trained with the Morph data. To have a deeper insight into the facial BMI analysis and a better understanding of various methods for facial feature extraction to map to BMI values, Jiang & Guo [8] performed a systematic study and evaluation of different facial feature extraction methods, through comparisons with the same experimental conditions and protocols. The involved features have two broad categories: (1) geometric features, e.g. those used in [4], like cheek-to-jaw-width ratio (CJWR), face width-to-height ratio (WHR) and face perimeter to area ratio (PAR), and some other geometric representation, e.g. pointer feature (PF)-68 facial fiducial points. The combination of these two different geometric features is also examined; (2) deep convolutional networks based features, e.g., the VGG-face, light CNN, and center loss deep networks. To validate the methods of the two broad categories, two datasets were used in [8]. One is the Morph dataset, a controlled case for face image acquisition, with 29,033 face images of 9,693 subjects, and another is collected in the wild (i.e. unconstrained), with 7,930 face images of 4,881 subjects. The experimental results show that the geometric features can be computed efficiently, which can deliver satisfactory results, especially when the number of training examples is small. The deep learning based approaches can take much longer for training; however, they are generally more robust, especially when head-pose angles change away from frontal views.

In addition to exploring facial BMI analysis, Jiang & Guo [9] presented a study very recently on using the 2-dimensional (2D) body images for BMI estimation. This is the first work of its kind, showing that the 2D body image analysis can be useful for BMI computing, especially when the facial parts are not visible, or occluded by other objects. The approach has some main steps: (1) human body detection, (2) body skeleton localization, (3) body feature extraction, and (4) regression. The experimental results on their own collected wild (unconstrained) body dataset [9] can achieve a reasonably good estimation of the BMI.

Large Scale Surveillance and Interventions

The developed AI technologies [4-6,8,9] for BMI analysis and computation have been overviewed briefly. While these AI technologies are being further improved or refined, they provide a great potential for large scale applications, such as obesity surveillance and interventions. For these technologies to be put into practice for obesity surveillance, an app can be developed to connect many users. Through analyzing the uploaded face and body photos by each individual on the app, AI technologies can be used to estimate the BMI or change of BMI for each subject over a time period. By aggregating the BMI estimations for people in a certain location, the obesity surveillance can be achieved. Furthermore, this kind of surveillance can be performed continuously in the long run. Another way involves using government or local state resources, by creating servers or websites to request people in a certain area to upload their face and body photos for analysis and surveillance. Compared to the current surveillance system, which is mainly based on telephone calls and personal interviews, the AI technologies can make the surveillance system less expensive, less labor-intensive, and more efficient. For obesity interventions, the Internet and/or smart phones can be taken advantage of. People detected with obesity by AI technologies can be notified regularly to remind them to pay attention to their body weight and life habits by providing appropriate guidance and instructions.

Finally, in adopting AI technologies for online surveillance and interventions, an important issue - which should not be neglected- is to protect the users' privacy. The human face and body images could contain personal private information. There has to be an implementation of strict policies and limitations to address the related privacy and security issues.

Conclusion

Obesity and diabetes are detrimental problems for public health. The developed AI technologies related to BMI and obesity have been presented briefly, which may be applied to promote an innovative approach to surveillance and interventions in obesity for public health. In turn, the AI technologies could be further improved and refined, driven by the large scale applications, to serve people better.

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