Computational Personality Traits Assessment: A Review

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Abstract— **Computational personality traits assessment is one of an interesting areas in affective computing. It becomes popular because personality identification can be used in many areas and get benefits. Such areas are business, politics, education, social media, medicine, and user interface design. The famous statement "Face is a mirror of the mind" proves that person's appearance depends on the inner aspects of a person. Conversely, Person's behavior and appearance describe the person's personality, so an analyze on appearance and behavior gives knowledge on personality traits. There are varieties of methods have been discovered by researchers to assess personality computationally with various machine learning algorithms. In this paper reviews methods and theories involved in psychological traits assessment and evolution of computational psychological traits assessment with different machine learning algorithms and different feature sets.**

Keywords—computational personality assessment; Machine Learning (ML), Deep Learning (DL)

I. INTRODUCTION

Computational personality assessment becomes popular in computer vision because it can be applied to many areas and get benefits. For an instance, in a job recruiting process it may lead to a wrong conclusion, if an employee select employer using the normal procedure as conducting interviews and written tests because the candidates may have prepared for the situations. But applying personality test can solve the problem of finding suitable persons for an appropriate profession. Not only in the job recruiting process, but also in fraud detection, politics, education, medicine, social media, businesses, and user interface design can apply computational personality assessment. In criminal identification, criminal behavior analysis assists defense authorities and lawyers to do their responsibilities in an effective and easy way. In education sector, teachers can assess the personality of the students and increase the effectiveness of the teaching-learning process by providing better materials by considering psychological states of the students. Assess the personality of the patients' leads to identify their psychological states and which helps better treatment process and also leads to identify psychological diseases. Nowadays analyzing the personality traits of social media account holders becomes popular and topical because of the crimes happen through social media. Also, user interface

designers can get benefits from personality information of the audience when designing user interface to enhance interaction in a user-friendly manner. Such as web sites and software interfaces designing can be developed based on knowledge of users' personalities and their preferences. Additionally, computational personality traits assessment is helpful in modeling social robotics to interact with humans.

Computational personality assessment is a combination of psychology and machine learning algorithms. According to the psychology, persons' behavior and appearance often depend on the persons' personality. There are various personality schemas defined in psychology, but the most acceptable schema is "Big Five" personality schema [1] which describes human personality as a vector of five values, they are extraversion, agreeableness, openness, conscientiousness, and neuroticism. According to the research article [2] the five traits can be summarized as follows with subordinate personality traits.

- Extraversion: Friendliness, Gregariousness, Assertiveness, Activity Level, Excitement-Seeking, Cheerfulness

- Agreeableness: Trust, Morality, Altruism, Cooperation, Modesty, Sympathy

- Openness to Experience: Imagination, Artistic Interests, Emotionality, Adventurousness, Intellect, Liberalism

- Conscientiousness: Self-efficacy, Orderliness, Dutifulness, Achievement-striving, Self-discipline, Cautiousness

- Neuroticism: Anxiety, Anger, Depression, Self-consciousness, Immoderation, Vulnerability

Additionally, the research article [2] stated that Big Five personality taxonomy does not provide a systematic framework for distinguishing, ordering, and naming types and characteristics of individuals, but Big Five structure has the advantage that everybody can understand the words that define the factors and disagreements about their meanings can be reconciled by establishing their most common usage. The "Big Five Inventory" a questionnaire which is used to measure Big Five personality traits depend on the scoring values given by the user also has been introduced in this paper.

There are research works done on this area with different technologies and different data set. Such as different data collection methods, different feature sets, different feature extraction methods, and different machine learning algorithms have been used. Although some research works focus on finding better machine learning algorithm on computational personality assessment while some others focus on get better accuracy of selected algorithms by modifying those algorithms. Machine learning algorithms have been used in this context as follows: artificial neural networks, support vector machines, convolution neural networks. These researchers have been used different feature sets such as video, audio, image data, and social media data.

The purpose of this research paper is to review the evolution of computational personality assessment and discuss emerging technologies used to identify personality traits with psychological concepts. The rest of the paper is organized as follows: section 2 includes a literature review, sections 3 describes methods involved in psychology to identify personality traits from the face, section 4 introduces face reading techniques, section 5 discusses the significance of computational personality assessment with deep learning, section 6 includes the conclusion and finally section 7 includes future works.

II. LITERATURE REVIEW

Researchers in this area used different feature sets, such as face images, videos, speech, handwriting and social media data to identify inner personality traits with different machine learning algorithms such as artificial neural networks, support vector machine, fuzzy logic and combinations of algorithms with deep learning concepts.

A. Face Based Personality Assesessment

Face based personality assessment is popular among apparent personality detection researchers. The research works [3, 4] have been used face images to identify personality traits of a person. To extract features, both the authors have used physiognomy, and in the training process, they have used N-fold cross-validation to overcome the fault that may occur due to less no of training images. In the training process [3] have used the artificial neural network and multi class support vector machine algorithms separately to compare results obtained from both methods and as they stated better results have been obtained from artificial neural network. In the research work [4] in addition to face image they have used fingerprint images to predict personality. To extract features automatically from the face they have used LBF (Local Binary Features) method which detected 21 facial salient points. Minutia-based fingerprint representation has been used to extract features from fingerprint images. In the training process classification and regression methods have been used to analyze accuracy and fitness of both methods. In the training process, they have performed experiments on men and women data separately by considering that there is a difference between men and women facial composition. In the training process as classification algorithms: Parzen Window, Decision Tree, K-Nearest Neighbor (KNN), Naive Bayes and Random Forest and in regression Linear Regression, Ridge Regression, Lasso Regression, Pseudo-Inverse Regression, K-Nearest Neighbor (KNN) Regression and Support Vector Regression have been used. Finally, they have stated that in classification the personality traits of females can be predicted more accurately than male using machine learning algorithms; predicting the intelligence level is difficult; and female facial features appear to be more closely related to measured intelligence than males. Also, in both classification and regression experiments, the results show that for the appearance feature, the performance on segmented images is better than that of cropped images, which concludes that segmentation processing is more effective at removing irrelevant information.

B. Video Based Personality Assessment

Personality recognition from video data relates to personality extraction from image data and audio data since analyzing video includes analyzing frames (images) and audio data. In the research paper [5], they have performed an in-depth analysis of audio-visual, text, demographic and sentiment features for multi- modal personality recognition task using the logistic regression learning model on a YouTube personality dataset.

There are several research works [6, 7] done on video data in the ChaLearn Looking at People Apparent (LPA) Personality Analysis competition. In [6] they have used Xiong and de la Torre's Supervised Descent Method (SDM), also known as an interface for detecting and aligning face. This method automatically locates 49 landmarks on a face. As mentioned in the article after face is detected it is inputted to pre-trained deep convolution neural network. The research work [7], the winner at ChaLearn LPA Personality Analysis competition 2016 used deep learning in their bimodal systems that is single hidden layer neural network was used for audio modality regression, while pre-trained deep convolutional neural networks were used for video representation and regression. In the both research works they have used transfer learning in their researches by using pre-trained deep convolution neural networks.

C. Audio Based Personality Assessment

There are researchers like [8, 9] done personality recognition on audio data using support vector machine and sequential floating forward search algorithm. First, they have extracted features from audio data and then they have applied defined algorithms on data extracted from features of the audio.

D. Handwriting Based Personality Assessment

Recognition of personality traits based on handwriting is also applicable because handwriting describes person's mental state and their inner personality types. Handwriting is different from person to person, it is because of handwriting is neurological patterns in the brain. These neurological patterns are used to identify personality traits. Handwriting is different from size, starting strokes, ending strokes, spacing letters between letters, writing pressure and so on. Analysis of handwriting based on strokes and patterns is a science called Graphology, which can be used to identify the personality of a person [10, 11]. In [10] they have identified that using baseline and the pen pressure in handwriting reveals a lot of accurate

information about the writer's personality. In this research work they have used Artificial Neural Network (ANN) as the machine learning algorithm and the baseline, the pen pressure and the letter "t," as found in an individual's handwriting used as input to ANN. The outputs of the ANN are the 30 different personality traits of the writer depending on the way crosses "t", the pressure with which writes and the baseline of the writing. The research work [12] used fuzzy logic to identify personality traits by analyzing handwriting. There are research studies like [13, 14, 15] also used the artificial neural networks as learning algorithm to identify personality traits from handwriting.

E. Personality Assessment on Social Media Data

Recognition of personality traits using social media data becomes very popular and topical. Researchers used profile images, comments, and profile size to identify personality types of Facebook account holders. The article [16] describes how interaction style at Facebook depends on personality type. They have used the Facebook Graph API to collect data from public Facebook accounts. Their system takes two inputs: first one is unlabeled text data with the authors and the second one is a set of correlations between personality traits and linguistic features. The system generates two outputs, first one is one model of personality for each author and second one is a confidence score for each personality trait of models. They have built a correlation between personality and written text (Facebook comments) to assess personality traits from Facebook interaction style. The research work [17] has done a study on identifying correlations between users' personality and the properties of their Facebook profiles with regression algorithms. In this study, they have used the size and density of their friendship network; number of uploaded photos, number of events attended, number of group memberships, and the number of times a user has been tagged in photos as properties of the Facebook profile. Multivariate regression algorithms have been applied to predict personality traits. They stated that best accuracy is achieved for Extraversion and Neuroticism, the lowest accuracy is obtained for Agreeableness and Openness while Conscientiousness lying in the middle. The research [18] used Twitter account holders profile picture selection details to identify personality traits of account holders. They have analyzed correlations between personality measured through posted text and the face image features to identify personality traits from the face image.

In this review basically focus on computational personality assessment with the appearance of the person, features of the face. Table 1 and Table 2 give an insight of results obtained by different researchers in personality assessment with facial data and video data.

TABLE I. FACE BASED PERSONALITY ASSESSEMENT RESULTS

No.	Algorithms Applied	Feature Extraction Method	Results/ Comments
[3]	ANN and m-class SVM	Manually	0.80706 validation performance
[4]	Classification and Regression	Non-rigid registration approach	65% accuracy for Openness, Extraversion and Neuroticism. The

No.	Algorithms Applied	Feature Extraction Method	Results/ Comments
			accuracy is lower for Conscientiousness and Agreeableness

TABLE II. VIDEO BASED PERSONALITY ASSESEMENT RESULTS

No.	Algorithms Applied	Feature Extraction Method	Results/ Comments
[5]	Logistic regression model with a ridge estimator	Audio-visual features, Text features, Word statistics features, Sentiment features used	They stated that audio-visual and sentiment features useful in identification of extraversion, conscientiousness and emotional stability, while combination of selected audio-visual and text features are helpful in the prediction of agreeableness and audio-visual features a ects negatively to the prediction of openness to experience personality type.
[6]	Pre-trained/fine-tuned Deep Convolutional Neural Network	Automatically by the deep CNN (To align faces used IntraFace method)	90.94% accuracy level
[7]	Visual modality: Res-Net, Descriptor, Aggregation Network (DAN), DAN$^+$ Audio modality: The Logfbank feature, Linear regression	Automatically	91.30% accuracy level

III. METHODS INVOLVED IN PSYCHOLOGY TO IDENTIFY PERSONALITY TRAITS FROM THE FACE

The research article [19] describes that physiognomy, phase facial portrait and ophthalmogeometry as three different methodologies involved in extracting features from the face which leads to identify personality traits from the face.

A. Physiognomy

The Backbone of physiognomy dates back to ancient Greece and is still very popular. The word physiognomy simply means judging or describing the nature. That is physiognomy refers to identify person's psychological characteristics or personality using outer appearance, basically using the face. Physiognomy also refers the relatively

unchanging facial features which might use to interpret inner or hidden aspects of a person. These features include details of the forehead, eyebrows, eyes, nose, and mouth. Analyzing these facial features leads to have an idea about the person's personality traits. Some people believe that it's not possible to deduce person's characteristics using the features of the face, but there are research studies proved that the possibility of deduce person's characteristics using face images. In 1772 J. C. Lavater said that physiognomy is a science and he proved the truth of the physiognomy on his book "Essays on Physiognomy". This is a historical article about physiognomy and it is still accepted. For thousands of years, researchers try to study the relationship between psychological characteristics and facial features. After doing researches in this area they have reached to a conclusion that persons' personality can assess via the facial features with a high degree of confidence. The evidence in real life to say that physiognomy is true is people who look alike tend to behave in the same way or at least they have common behavior. Human got outer appearance from genes that are from the parents and ancestors. Because of that children have the same appearance to their parents. This implies that children and their parents should have approximately same personality profile. In day-to-day life social conversations, people say something like "She is kind just like her mother" which prove the truth of the physiognomy. But there is no evidence that physiognomy works, but recent studies have stated that facial appearances do "contain a kernel of truth" about a person's personality. Computational personality assessment with physiognomy is measuring feature values as shown in the Fig. 1.

B. Phase Facial Portrait

Phase facial portrait is mainly based on calculating angles of facial feature lines and directions as shown in the Fig. 2. The extracted features that are angles and directions are used to identify personality traits.

C. Ophthalmogeometry

Ophthalmogeometry is based on the idea that persons' emotional, physical and psychological states that can be recognized by 22 parameters of eyes part of the face. Eyes are different from person to person and that's why biometric security applications also use features of the iris. So, it can be concluded that ophthalmogeometry can be used to identify how persons differ from each other that is inner aspects of the persons. But this method is not very deeply investigated area of facial analysis, which primarily needs automation of ophthalmogeometric pattern extraction and further investigations. Fig. 3 demonstrates the measurements taken in the process of Ophthalmogeometry as described in [20].

Computational personality assessment researchers most familiar with the physiognomy method, because the data extraction is easier than other two methods and also involves full face feature extraction.
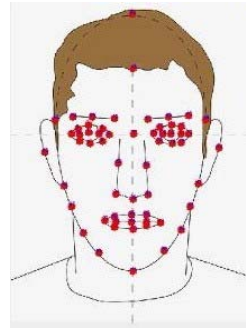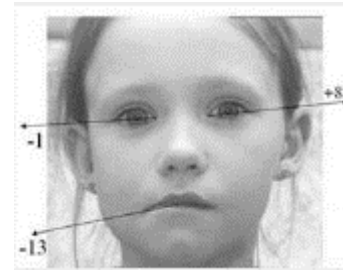

Fig. 1 Example of measuring feature values in physiognomy

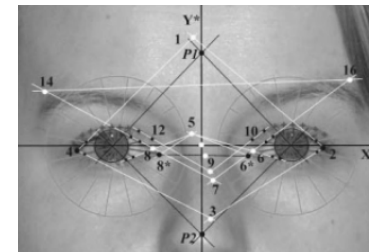Fig. 2 Example of measuring feature value in phase facial portrait

Fig. 3 Example of measuring feature values in Ophthalmogeometry

IV. FACE READING

According to [21] face is an insight into a person's emotional, mental and physical patterns that occur on a daily basis. Because of that face reading gives an instant insight into a person's character. Also, facial reading can also determine a person's constitution, current health status, long-term health prospects and psychological and emotional profiling for career and self-understanding as all the aspects of the face can be subject to interpretation. The front view of the face describes how a person face the world, while the face profile indicates that how a person projects his/her personality into the world. All aspects of the face are taken into account including: the overall face structure and shape; the placement, color and shape of the eyes; the shape, size and direction of the nose; the curvature and thickness of the eyebrows; and much more. Fig. 4 shows different shapes of the face. According to the psychology round face describes sensitive and caring, has good relationships; oval describes balanced, sweet, charming, artistic, but sometimes they can be dangerous, temperamentally are weak, often weaker in physical strength, sometimes underactive; oblong faces describes practical, methodical and tend to be a bad more overworked, frailer in relationships and so on.
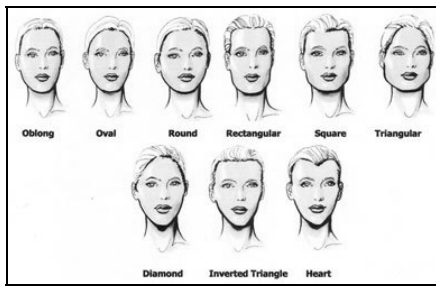
Fig. 4 Different shapes of the face

Different forehead styles describe different personality traits such as wide forehead defines busy and thinking brain; swollen center defines strong memory; swollen center defines fast thinking brain; swollen bottom defines skillful at job and in arts; hollow center defines arrogant; small forehead defines mental deficiency person; high and swollen forehead defines intelligence and understanding; flat and straight forehead defines sick frequently; and narrow and low forehead defines stubborn and not thinking brain. Likewise, there are identified styles by psychologists for different features of the face, which describes different personality traits.

V. SIGNIFICANCE OF COMPUTATIONAL PERSONALITY ASSESSMENT WITH DEEP LEARNING

Deep Learning (DL) is emerged to machine learning research from 2006. DL is also called as deep structured learning or hierarchical learning. Artificial Neural Networks (ANN), Support Vector Machines (SVM), Logistic Regression and Hidden Markov Model (HMM) are known as shallow architectures. For an example SVM uses a shallow linear pattern separation model with one or zero feature transformation layer. Shallow architectures showed good results when dealing with real world problems, but in some context, have to face difficulties with those shallow architectures. For an example, when choosing the input to the ANN, it should choose depending on the problem. So, suggest the need of deep architectures for extracting complex structure and building an internal representation from rich inputs. For an example, the image classification system gets input as an image. So, there is no manual feature extraction stage, which helps researchers to do their research without having much knowledge of the domain of the problem. The Foundation for DL is an artificial neural network and feed-forward neural network with many hidden layers which are often referred to as deep neural networks. DL is a set of algorithms in machine learning that attempts to model high level abstractions in data by using architectures composed of multiple non-linear transformations.

Recently with the introduction of DL the field of computer vision has become improved with the use of DL. Within the last five years Convolution Neural Network (CNN) became popular with ImageNet classification challenge. AlexNet (2012) [22] reached to top 5 test error rate of 15.4%. ZF Net (2013) [23] achieved 11.2% error rate. VGG Net (2014) [24] optimized it to 7.3% error rate. GoogLeNet (2015) [25] obtained a top 5 error rate of 6.7%. Microsoft ResNet (2015) [26] obtained an incredible error rate of 3.6%, while the human

error rate generally around 5-10%. These research facts proved that computer vision becomes improved with thr introduction of DL.

DL consists of Convolution Neural Networks (CNN), Recurrent Neural Network (RNN) and Deep Belief Network (DBN) and more. CNN recently gains a huge success in image and video classification [28]. Large scale classifications become possible with the availability of large image sets such as ImageNet; and with high processing power of machines such as Graphical Processing Unit. Also, DL has been successfully applied in face recognition [27], object recognition [29] with convolution neural networks and emotion recognition [30] with the deep belief network.

CNN is considered as "Black Box" like artificial neural networks because when it comes to elucidating exactly how their results are generated. But to make deep learning more understandable to researchers and users, it is more important to learn how these networks are able to correctly perform and what went wrong if they make some mistakes. In [23] have described a method to overcome this problem by visualizing convolution neural networks. According to the authors it is very important to understand how CNN performs so well, or how they might be improved. For that they have introduced a novel visualization technique that gives insight into the function of intermediate feature layers and the operation of the classifier. They have presented a novel way to map these activities happen in CNN back to the input pixel space, showing what input pattern originally caused a given activation in the feature maps. They have performed this mapping with a deconvolutional network [23]. A deconvnet can be thought of as a convnet model that uses the same components (filtering, pooling) but in reverse, so instead of mapping pixels to features does the opposite. To examine CNN deconvnet is attached to each layer.

Personality detection with deep learning becomes a new area in machine learning research. Deep learning produces better results than other machine learning methods such as artificial neural network, support vector machine, etc. It is because, in previous machine learning techniques, features are extracted manually or using automatic tools. When extracting features manually there could be errors happened due to human faults and important information may not be included in the automatic methods as psychologists extracts features based on psychological theories. But in DL feature extraction is done by the network itself. Because of that using DL may get better results than other methods as artificial neural networks, support vector machines, etc. Not only that DL with large datasets shown that they are robust to variations exhibited in the data, and also using 'deconvnet' can be used to identify the features that are correlated with a selected personality. This will leads to prove the psychological theories.

VI. CONCLUSION

In this review, we have discussed the methods and techniques used in computational personality assessment with machine learning algorithms and recent trends in computational personality assessment with deep learning. Various deep learning techniques have been developed for

large scale image classification problems such as AlexNet, GoogLeNet, and Microsoft ResNet and they gave better results in ImageNet classification challenge. These models have been applied and adjusted for recognition of psychological characteristics from the facial features. The use of pre-trained model in new classification task is called as transfer learning. The transfer learning can be used to reduce the high processing requirement in deep convolution neural networks and obtain better results. The challenging problem of DL is that it needs a large dataset. As a solution for this problem, various augmentation methods can be used to increase the size of the dataset. In this field, researchers mainly use BIG FIVE psychological personality schemas to identify personality traits from different features of the persons such as images, audio, and video. But still this structure has some disadvantages according to psychologists.

VII. FUTURE WORKS

Computational personality assessment becomes popular because of the necessity of having an automatic personality detection system. Additionally, with the development of convolution neural network and high accuracy of deep convolution neural networks this area becomes popular. But still there is a lack of information to prove the existence of psychology theories which are used to predict personality from the outer appearance. That is lack of computational methods to identify the relation between personality traits and facial features. It is very useful and essential to identify relationships between facial features and personality traits with the high accuracy of the personality traits assessment systems.

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