

Automatic Recognition of Personality from Digital Annotations

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Abstract: There is an increasing interest in understanding human perception based on reading and writing behaviours. Such researches are interested to seek knowledge of an individual's personality as a way to predict their behaviours and preferences across different contexts and environments. Recent works show significant relation between the reader personality and his reading behaviours. Based on these findings, annotation activity is considered as potential source to predict certain personality traits of readers. In this paper, we take advantage of such theoretical works and we propose an online environment of active reading used to explore practically the utility of annotation in reflecting an accurate user personality profile. We apply the paired t-test to evaluate the system's efficiency to measure human traits versus the scores of personality traits measured using the Neo-IPIP inventory. Our findings show plainly that some traits of users' personalities can be predicted accurately from digital annotation traces during online reading session.

1 INTRODUCTION

The psychological researches show that personality traits are consistently stable over time and constitute a significant inter-individual difference (Burger, 2011; Cobb-Clark and Schurer, 2012). This stability is considered as the key-assumption of personality psychology which has the aim to predict observable individual differences based on human traits characteristics that is measurable in quantitative terms (Matthews et al., 2009). The findings of personality psychology area interested increasingly the computing community which leads to the growth in number of research paper in the topic of personality computing (Vinciarelli and Mohammadi, 2014).

Many scholars are motivated to model users' traits and they are interested to seek knowledge of an individual's personality as a way to predict their behaviours and preferences across different contexts and environments (Bologna et al., 2013; Selfhout et al., 2010).

To assess user's personality traits, several works control user's behavioural residues traces in the digital environments (Kosinski et al., 2013). For instance, (Bachrach et al., 2012; Golbeck et al., 2011; Quercia et al., 2011) have analyzed the relationship between personality and users' behaviours in on-line social environments. The

works' findings show that users' personalities can be accurately predicted through their traces in social profiles.

There is an increasing interest in understanding human perception based on features extracted from reading and writing behaviours. To show the ability to profile user personality from human text production and peculiarities of reading behaviours, many researchers study the relation between user's personality traits and several factors such as text (Wright and Chin, 2014; Celli, 2012; Arya et al., 2012), linguistic cues (Celli and Poesio, 2014; Mairesse et al., 2007; Celli, 2012a), handwriting styles (Rahiman et al., 2013; Prasad et al., 2010; Fisher et al., 2012), posts written in online social spaces (Iacobelli et al., 2011; Sumner et al., 2012; Qiu et al., 2012), social annotation (Mezghani et al., 2012) and annotation traces during active reading sessions (Omheni et al., 2014; Jackson, 2001).

The present work focuses on development of an automated technique for determining the personality traits of a user through analysis of digital annotation traces in online reading environment.

The rest of this paper is as follows. In the next section, we present an overview on related works. Then, we propose an automated method to predict accurately certain traits of users through their annotation practices. Thereafter, we evaluate the system's performance to measure precisely the

scores of users' traits. Finally, we draw some conclusions and we cite certain possible directions for future work.

2 RELATED WORKS

The computing community is interested increasingly to seek knowledge of an individual's personality as a way to predict their behaviours and preferences across different contexts and environments (Vinciarelli and Mohammadi, 2014).

The human personality is viewed from different perspectives: biologically, psychoanalytically, behaviourally, humanistically, cognitively, trait perspective, etc. The most accepted model in computing area is the trait perspective. Indeed, the trait based model represents personality in terms of numerical values which is a form particularly suitable for computer processing (Vinciarelli and Mohammadi, 2014).

Commonly, personality traits are assessed using self-report techniques (Boyle and Helmes, 2009). In computing area, the most popular technique used to assess personality traits is the NEO-Personality-Inventory, where the user rates his own behaviour with Likert scales. For instance, (Nunes et al., 2008; Nunes et al., 2008a) propose obtaining users' personality information through their answers to the NEO-IPIP inventory. The participators in the authors' experimentation were instructed to answer 900 questions. 10% of people answered all the questions of the testing because they aren't ready to spend much effort for a long time to complete a multi-item questionnaire. (Hu and Pu, 2010) use the TIPI test (Ten-Item Personality Inventory) developed by (Gosling et al., 2003) to acquire the user's personality characteristics. This inventory is an extremely brief measure of the Big-Five personality dimensions so the acquisition process takes about 2-3 minutes to complete. Further research works follow the same path to calculate the user personality scores where each subject was instructed to fill in a big five questionnaire (Tkalcic et al., 2009; Wu et al., 2013).

Although the results shown in previous works is fruitful we believe these researches have left certain open issues concerning the followed approach to obtain the information needed in the user modelling process. Indeed, the crucial constraint in the profiling process is to model a credible user's profile which reflects truly as much as possible the user in the working environment. The explicit methods require much from the user who is not ready,

usually, to fill long forms or even to write the truth when completing forms about themselves (Schiaffino and Amandi, 2009). Therefore, the main limitation of self-assessments technique is that the users might tend to bias the ratings towards socially desirable characteristics knowing that the web-based psychometric tests suffer of the control diminution over the testing situation which lead to the high probability of cheat especially in case where the motivation to do is obvious and the personality assessment can have negative consequences like, e.g., failing a job interview (Vinciarelli and Mohammadi, 2014; Barak et al., 2004; Gawronski and De Houwer, 2014).

Certain psychologists seek to alternative measurement instruments that reduce participants' ability to control their responses and do not require introspection for the assessment of psychological attributes (Gawronski and De Houwer, 2014).

According to Brunswick's lens model human personality is externalized through distal cues observable by others. These distal cues are essentially physical traces left by individuals' behaviours in virtually everything observable they do (Vinciarelli and Mohammadi, 2014). In this context, recent studies show the opportunity to derive personality from digital traces of human behaviours in different workspaces. Such works are interested to show how users' behaviours on Social Networks relates to their personality, as measured by the standard Five Factor Model (Kosinski et al., 2013; Bachrach et al., 2012; Golbeck et al., 2011). Other scientists study recognizing personality in user's speech and social interaction (Polzehl et al., 2011; Ivanov et al., 2011).

Actually, in personality computing area, there is a great interest to understand the human perception based on reading and writing behaviours (Rahiman et al., 2013; Wright and Chin, 2014; Minamikawa and Yokoyama, 2011).

In the current essay, we are interested to a specific behaviour of reading and writing activity: The annotations. Indeed, we conducted a previous work to show the relation between reader's personality and his annotation practices in "pen-and-paper" context. The experiment showed an interesting relation of correlation between certain peculiarities of annotation activity and the annotator's personality traits (Omheni et al., 2014). These findings motivate us to consider the annotation traces in the digital context and to test the possibility to recognize human's personality traits based on their digital annotations' traces in online reading environment.

3 ANNOTATION AND PERSONALITY

Annotation is a handwritten practice which bridges between reading and writing (Marshall, 1998) and constitutes the most prominent habits of active reading activity (Thomas, 2007).

(Kirwan, 2010, p. 5) considers the reader marginalia (annotation) as: the “most direct, reactionary response to the text that can feasibly be considered” to study the relation between the reader identity and the text. According to (Kirwan, 2010) the annotations provide the link between reader, text, and meaning and reflect the subjective individuality of the annotator’s responses to the text. Based on this subjective relationship, the author suggests expanding the psychology-based reader theory to include reader’s annotation practices.

The annotation activity is “a basic and often unselfconscious way in which readers interacts with texts” (Marshall, 2009, p. 38). Furthermore, the annotation is described as a natural human activity that is used in daily life as an integral part of reading activity (O’hara and Sellen, 1997). Every annotator has unique individual patterns in making annotations (Naghsh, 2007). According to (Jackson, 2001, p. 5), “if you ask annotators today what systems they use for marking their books and where they learned them, they generally tell you that their methods are private and idiosyncratic”. Hence, the individuality of annotation patterns shows us very plainly that there can be some sort of connection between annotation practices and annotator’s personality. (Jackson, 2001) assumes that “marginalia [annotation] express a reader’s impulsive and unguarded reactions to a book” and she “consider[s] them to be an exceptionally reliable guide to personality” (Jackson, 2001, p. 87).

In our prior work (Omheni et al., 2014) we conducted an empirical study to show the implicit relation between reader’s annotation activity and his personality traits. The study shows significant correlations for Neuroticism, Conscientiousness, and Extraversion traits. Furthermore, we made predictions about a subject’s personality based on multiple annotation features using the multivariate linear regression method. Our findings show that Neuroticism and Conscientiousness can be predicted with reasonable accuracy, whereas other traits are more difficult to be predicted.

Regarding the external validity of our findings, first of all, in our study, we addressed the population characterized as following: people aged between 18 and more, either man or woman, with different

occupations and interests and who practice frequently the habit of reading and annotation of textual materials. Hence, the size of population is so large, which is in reality, not possible to sample the whole population, due to budget, time and feasibility. Thus, as a way to decide pragmatically the generalization of our findings we made on the basis of the selection of a sample group that is representative of the target population. This is something that we took into account when designing our experiments. Our research design is governed by the interest in the generalisability of our study’s results. Hence, we do a good job of drawing a representative sample from our addressed population and we have not considered specific circumstances of time and place in which the data were collected. Indeed, in our study, we focus on the annotation practice which is a ubiquitous human behaviour and we have only considered the paper support of annotated document. To measure the personalities scores of volunteers we utilized the standard Five Factor Model questionnaire (the NEO-IPIP Inventory) which is the best accepted and most commonly used scientific measure of human personality traits (Peabody and De Raad, 2002). All the tools and circumstances taken into account to achieve our experiment can be considered in a variety of places, with different people and at different times. Thus, based on logical considerations and speculation concerning the extent to which our sample is similar to the target population and the replication of our experiments with other representative groups in other locations can strongly give the same results and findings, we ensure that we can generalize our findings to the entire population in our study.

4 RECOGNITION OF READER TRAITS BASED ON DIGITAL ANNOTATION PRACTICES

Based on what previously cited, it is plain, that a reader’s annotation activity is really an expression of his personality traits. Indeed, we show very plainly that the considered features descriptive of the annotation practices in our prior study may appear insignificant in themselves, but, they are nevertheless all very significant as indications of the annotator’s personality traits (Omheni et al., 2014).

Recent researches endeavour to replace the “pen-and-paper” paradigm for the annotation needs by employing the technology of free form digital ink

annotations which add the flexibility and natural expressiveness of the traditional handwriting method to the digital annotation process (Kalboussi et al., 2015). Such tools enable readers to annotate their digital documents similarly to “pen-and-paper” case. For instance, iAnnotate (Plimmer et al., 2010) is an annotation tool for android system which enables users to add annotations with the pencil, highlighter, and note tools to their digital texts. Hence, the digital context of free form annotation process is very similar to the context of pen-and paper. The high degree of proximal similarity among these two contexts constitutes a strong evidence to generalize our study’s results (Omheni et al., 2014) to digital annotation environment. Thus, we are motivated to take advantage of digital annotations which can be considered as a source of knowledge to automatically predict an annotator’s personality traits.

In this subpart of our study, we focus on development of an automated technique for determining the characteristic traits of a person through the features extracted from his annotation activity. In fact, the proposed system “i-Read” is an online reading environment where the user can upload their reading materials and practice their annotation habit.

The following figure (fig.1) illustrates the interaction between the various modules of “i-Read” system along with the flow of information/data. The proposed architecture consists of user annotation interface, the annotation analyzer module, the constructor profile module and three databases with two servers.

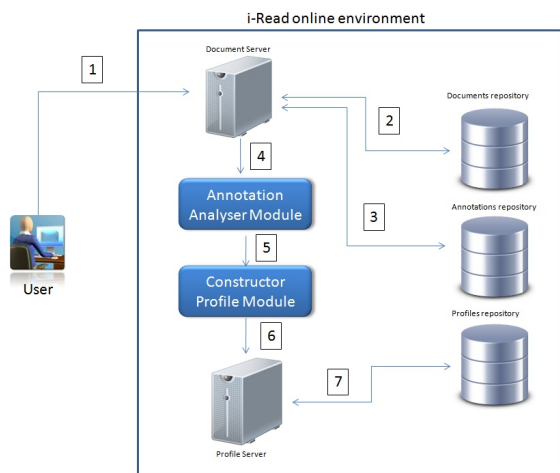


Figure 1: The Architecture of “i-Read” Online Reading Environment.

To avoid destroying the original version of reading materials, our system uses an independent annotation database, which differs from the documents database, to store annotated information and contexts from readers. Moreover, the annotation interface provides several powerful annotation functionalities, such as scribbling, highlighting, underlining, commenting, as a way to engage users actively with their reading materials.

4.1 The Annotation Analyser Module

To predict the actual personality traits of the individual we consider the features studied in (Omheni et al., 2014) to be extracted automatically by the module of annotation analysis. To extract the considered features we start, first of all, by classifying annotations in three general categories. This categorization is based on how annotations can appear and be represented. (Agosti and Ferro, 2003) define three ways to represent the meaning of annotation:

1. Textual annotation expressed by a piece of text added to the annotated document,
2. Graphic annotation expressed by a graphic mark added to a document,
3. Reference annotation expressed by a link between two texts or two textual pieces in the same document.

The authors called these basic ways “signs of annotation” and they define the term sign as a formation of a meaning. Furthermore, according to (Agosti and Ferro, 2003), these signs can be combined together to express more complex signs of annotation. In current work we try to quantify the user’s digital annotation traces by collecting a set of statistics describing the total number of annotations, average number of annotations per page of reading material, number of textual annotations, number of graphical annotations, and number of referential annotations.

4.2 The Constructor Profile Module

In our empirical study, we used the multiple linear regression analysis to assess the association between six independent variables representing the different features qualifying the annotation activity and a single continuous dependent variable represents the focused user’s trait. The multiple linear regression equation is as follows:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 \quad (1)$$

where Y is the predicted or expected value of the dependent variable representing the score of the focused user's personality trait, X_1 through X_6 are the distinct independent or predictor variables, b_0 is the value of Y when all of the independent variables (X_1 through X_6) are equal to zero, and b_1 through b_6 are the estimated regression coefficients. Based on this mean function, we can determine the expected annotator's personality trait as long as we know certain peculiarities characterizing quantitatively her annotation practices.

As we cited previously, based on the similarity between the two contexts of annotation process (the manual and digital contexts) we have generalized our study's results to the digital environment. Thus, in current work, we are motivated to apply the study's findings (Omheni et al., 2014). The scenario of the proposed automatic personality profiling is as follow: first of all the annotation analyzer module captures certain features which tend to characterize quantitatively the reader's annotation practices. The collected data is used thereafter as a source of knowledge to extract the implicit information which describes the personality of active user. Indeed, the quantitatively information is transferred to the constructor profile module as an input data to the equations used to estimate the scores of user traits profile.

4.3 System Operation Procedure

Based on the system architecture (fig.1), the system operating procedure is described and summarized as follows.

1. A user uploads his/her reading document on the "i-Read" online environment;
2. The system saves the document in the documents repository;
3. The user annotates his/her reading material;
4. The system saves the user's annotations in the Annotations repository;
5. The annotation analyzer module captures the user's annotation activity and extracts such features;
6. The annotation analyzer module sends the collected information to the profile constructor module to build the user personality traits profile;
7. The profile constructor module considers the collected information as an input data to the equations used to estimate the scores of user traits profile;
8. The system saves the modelled user's profile in the Profiles repository.

4.4 System's Performance Evaluation

In order to evaluate the system's level of performance in measuring accurately the scores of reader's personality traits, we conducted the following experiment and we invited 100 volunteers. The invited people have the same characteristics qualifying the target population in our prior work (age, gender, habit of reading and annotation). To assess whether our system measures accurately the user's traits, we invited the participants to upload their textual materials on the "i-Read" environment and we instructed them to use the system to achieve their reading and annotation activities (fig.2). Next, they were instructed to answer a standard Five Factor Model questionnaire (the NEO-IPIP Inventory) to obtain a feedback regarding their personality based on their responses.

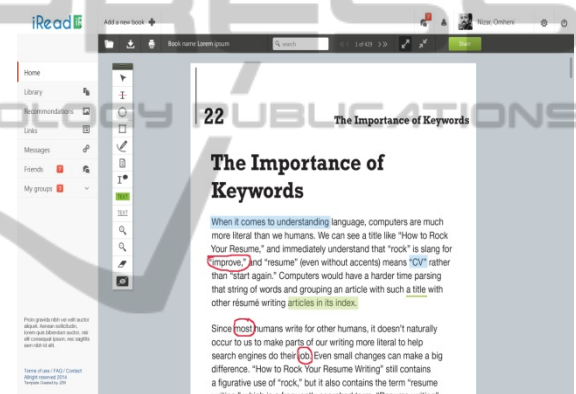


Figure 2: Annotated document opened in "i-Read" online environment.

To show the system's efficiency to measure accurately the scores of reader's conscientiousness and neuroticism traits compared to the values determined using the NEO-IPIP Inventory, we applied the paired t-test to compare the scores of certain user's personality traits obtained through the two different methods of measurement. We look to determine whether there is a significant difference between the paired values of scores. Both measurements are made on each subject in the selected sample, and the test is based on the paired differences between these two values. The test statistic is calculated as following:

$$t = \bar{X} / \sqrt{s^2/n} \quad (2)$$

\bar{X} is the mean difference, s^2 is the sample variance, n is the sample size and t is a Student t quantile with $n-1$ degrees of freedom. In our case $n = 100$. Tables 3 and 4 show descriptive statistics of t -test measure of the difference significance between the paired

values of user's conscientiousness and neuroticism traits scores measured with two different systems: the "i-Read" system and the Neo-IPIP inventory.

Analytical results indicate that the scores of user's Conscientiousness and Neuroticism characteristics obtained through the "i-Read" system did not differ significantly (Sig1 = 0,72 > 0.05; Sig2 = 0,53 > 0.05) versus the scores measured using the Neo-IPIP inventory (Table 1. and 2.). Thus, the experimental results show the possibility to measure some personality traits (Conscientiousness and Neuroticism) with reasonable accuracy by reference to reader's digital annotation practices.

Table 1: A t-test measure of the difference significance between the paired values of Conscientiousness scores measured with two different systems.

Scores measured with	Mean	Std.Dv.	t-value	p-value
"i-Read" system	25,78	4,90		
Neo-IPIP inventory	26,50	20,25	-0,36	0,72

Table 2: A t-test measure of the difference significance between the paired values of Neuroticism scores measured with two different systems.

Scores measured with	Mean	Std.Dv.	t-value	p-value
"i-Read" system	64,66	6,74		
Neo-IPIP inventory	63,37	21,16	0,63	0,53

These results is coherent to our prior findings (Omheni et al., 2014) and support the hypothesis of the existence of some sort of connection between annotation traces and certain personality traits of the annotator. These discoveries are promising and constitute a new tendency in modelling human traits by reference to certain behavioural residues of reading and writing activities.

5 CONCLUSIONS

In this paper, an automated method has been developed to predict certain personality characteristics of a person from features extracted through his annotation behaviours. We have proven that some traits of users' personalities can be predicted accurately from digital annotation traces in online reading environment. This shows us very

convincingly that there is some sort of connection between the peculiarities of annotation activity and certain personality traits of the annotator.

We want to enhance the proposed system to be used in personality-based systems. Another future direction, we want to increase the features used to derive user's personality traits based on their annotation practices for more correct results. These investigations can be subjects of follow-up works in the near future.

The current work can be complementary to the prior works of (Kalboussi et al., 2014; Kalboussi et al., 2013; Kalboussi et al., 2013a; Kalboussi et al., 2013b) which aim to invoke the web services based on annotation activity of a reader. Thus, our work can be useful in the adaptation process of the invoked web services. As a summary, we can consider the modelling process of reader's personality based on annotation traces is a step forward in the area of personalization over web.

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