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Original Article

Improving Online Experience using Trust Adjustment Factor for Recommender Systems

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Abstract - *With the improvement of computing Technologies, online shopping has become a norm to the way of life. Aggravated by the global pandemic, COVID 19, the need for social distancing has even increased the demand for online shopping as people try to stay or work at home but still run their day-to-day errands. Unscrupulous vendors have realized this sudden shift to the online market and are trying to take advantage of inexperienced shoppers by luring them using various techniques and finally ending up defrauding them or harming them physically. There exist mechanisms to help shoppers choose the right product or services, such as the use of recommender systems to help users choose a product, but the loophole again is that the recommender systems depend on historic data to make their decisions. This data can still be manipulated by unscrupulous practitioners. There is a need to take care of this loophole in the recommender system. In this study, we carried out research on what Kenyans perceive as trust; we then used the Structural Equation Modelling technique to create a parameter known as Trust adjustment factor, which we are adding to the recommender system algorithm to take care of trust issues in online shopping.*

Keywords - *Ethics, Online fraud, Recommender systems, Structural equation modeling, Trust in online service providers.*

I. INTRODUCTION

Over the years, there have been significant advances in Information and Communication Technologies (ICT), resulting in increased availability of high-speed, reliable broadband internet services. Further, there has been a consistent reduction in the prices of computing gadgets such as smartphones and tablets. These factors have resulted in increased Internet penetration and utilization of online services.

Coupled with the need for social distancing as a means to curb the spread of the current global pandemic, COVID 19, the demand for online shopping has even gone higher as people try to stay or work from home but still remain desirous of having the day to day errands in track. Unscrupulous vendors have realized this sudden increase in online shopping and are trying to take advantage of inexperienced shoppers using various digital techniques, including but not limited to playing with the search engines like in the cases of unfair Search Engine Optimizations or just providing too many services online in a manner that simple process of decision making when choosing the suitable product becomes overwhelming to the online shopper due to information overload and therefore opens a risk that the shopper can make a mistake which works to the advantage of an unscrupulous online vendor.

Techniques such as recommender systems (Ricci, Rokach, & Shapira, 2011) have been used to alleviate the burden of information overload from the online shopper, where the recommender systems help the shopper to choose the most suitable product for their case. Again there is a loophole in the sense that these recommender systems still rely on historic data to arrive at their decisions. This data can still be manipulated by unscrupulous vendors to the disadvantage of the online shopper. (Amatriain, Jaimes, Oliver, & Pujol, 2011).

Scientific studies such as (Yin, Wang, & Park, 2017) have demonstrated that:

- Trust can be incorporated into recommender systems
- Trust based on sociology improves the accuracy of a recommender system.

However, this study was done based on data from epionios data set, where users were tasked to explicitly express their trust level to various online services. This is not only cumbersome to the users but also a reactive approach to the matter at hand since the user will only realize that the vendor is not trustworthy after the unscrupulous vendor has made a few successful hits on defrauding the online shopper. Again this Epinions dataset by (Richardson, Agrawal, & Domingos., 2003) is not only old but also the epinions website which was used to collect the data is no longer functional. This situation has necessitated that for the practitioners to benefit from the work of (Yin, Wang, &

Park, 2017), they must find a new way to construct trust as a parameter for recommendation systems algorithm.
In this study, we have also used the Structured Equation Modelling as the methodology to construct a trust parameter and added it to the recommendation system algorithm as a new parameter.

The rest of this paper is organized as follows. In section two, we discuss some of the previous research works that are closely related to this study. In section three, we present our proposed solution then present preliminary results in section four. We then discuss our results in section five and then conclude and give areas of future works in section six.

II. RELATED WORK

A. Trust based in sociology by (Yin, Wang, & Park, 2017).

In 2017, (Yin, Wang, & Park, 2017) incorporated trust in sociology into a recommender system algorithm and found out that the version of the algorithm, which included trust, was outperforming the other version, which does not incorporate the trust parameters in terms of the recommender system accuracy.

The study uses the Common filtering Recommendation Algorithm, with trust incorporated, named Common Filtering Recommendation Algorithm with Trust (CFRAT) and the Common filtering Recommendation Algorithm (CFRA) in its natural state as the control.

It is noted that when tested using the Mean Absolute Error and Root Mean Square Error tests, the CFRAT outperforms the native CFRA in terms of recommender system accuracy.

This study uses data from (Leskovec, 2003), this method of data collection is not only cumbersome to the users but is also just a matter of user opinions which is subject to bias. Also, it is a reactive approach since a user will come to learn that an unscrupulous vendor is dishonest only after the unscrupulous vendor has made a few successful fraudulent hits. This necessitates the need to come up with an autonomous and proactive way of deriving the trust parameter for use in the recommender system algorithm.

B. The Ethics of Online Retailing: A Scale Development and Validation from the Consumers' Perspective, by (Roman, 2007).

In theory, trust and ethical standards are greatly correlated in the sense that an online shopper is not likely to trust an online vendor who is deemed to have low ethical standards, and in essence, even if the recommender algorithm was to recommend a to a shopper purchase a product from a vendor whom the shopper perceives to have low ethical standards, the shopper will ultimately not buy from the said vendor on the basis of trust issues. This implies that one can use vendor ethical standards to predict his trustworthiness. In 2007, (Roman, 2007) carried out research to develop and validate a scale for measuring the ethics of online retailers from the consumer's perspective. The study used Structured Equation Modelling to identify indicators of ethics in online retailing from the consumer's perspective through the use of Exploratory factor analysis and Confirmatory Factor analysis. The validated factors include:

- Security
- Privacy
- Non-Deception
- Fulfilment of order/Reliability

This study provides scientific evidence that there exists a mechanism of estimating the ethical standards of an online vendor through indirect cues or indicators and, by extension, estimating the consumer's trust in an online retailer. In theory, these cues can be harvested in an automated fashion and be used to construct an estimator for online vendor's ethical standards, and hence his trustworthiness. If well designed, the results of this study can be used to automate a way of constructing a trust parameter for use in the recommender algorithm. The challenge is, in our view, about these results is that the study was done in a different context than our target context. Our target context is the case of Kenyan shopper's perspective of trust for online retailers. This study was, however, done in a European Context. The variation could be informed by factors such as differences in:

- Societal norms
- Economic Situation in two contexts
- Exposure to information
- Levels of Internet Penetration
- Interpretation of questionnaire items

Therefore, from the perspective of science, it will be incorrect to poach the results and apply them without the consideration of the context. As such, it is paramount that a similar study is carried out Kenyan target context, and the results of the target context are applied in a context-aware fashion in order to be used to construct a trust parameter for the recommender systems.

C. Context-Aware Computational Trust Model for Recommender Systems, b (Ngwawe, Abade, & Mburu, 2020).

Pursuant to the ongoing discussions, we have also carried out the first study in our target context and provided results of our exploratory factor analysis in our previous work (Ngwawe, Abade, & Mburu, 2020).
We found out the factors that drive how shoppers in Kenya purchase items online included:

- Security;
- Trust;
- Reliability of the site;
- Individual's purchasing power;
- Individual's Exposure to information

These were results of our preliminary study, which were,

in essence, the Exploratory Factor Analysis. It was then incumbent that we proceed with the second leg of the study, which would provide data for confirmatory factor analysis of our Final Trust Model.

D. More studies on context-aware recommender systems, by in (Gediminas & Alexander, 2011).

More work about Context-aware Recommender Systems can be found in (Gediminas & Alexander, 2011).

E. Other Mechanisms of trying to estimate trustworthiness on an online vendor, by (Jumia KE, 2021).

Another Mechanisms of trying to estimate trustworthiness on an online vendor, albeit reactive, is by providing a forum for users to rate the item they purchased and express their sentiments about the item after purchase. The data provided is then analyzed, and a decision is made about the vendor by the service aggregator, and this provides an indication of the vendor's trustworthiness. This is the methodology which is currently being used by one of major Kenyan online shopping mall called Jumia (Jumia KE, 2021). As stated, this process is reactive, and the trustworthiness of the vendor is established only after he has made a few successful fraudulent attempts.

III. PROPOSED SOLUTION

In this work, we propose to use Structural equation modeling (SEM) (Hox & Bechger, 2014), (Stein, Morris, & Nock, 2012). We had already carried out the first study and explored the factors that Kenyan shoppers look at when shopping online (Ngwawe, Abade, & Mburu, 2020). We then carried out a nationwide survey to confirm the findings of the exploratory factor analysis results. We created a questionnaire using Google Forms and sent out links using emails and also shared to the target participants through social media channels such as Whatsapp groups, this method of data collection is supported by the study on new approaches to assessing opinions by (Best & Krueger, 2002). In response, we got a total of 300 successful responses, which is satisfactory for SEM analysis of this nature as evidenced by the work of (Parasuraman, Zeithaml, & Malhotra, 2005), which suggests 200 as sufficient. The respondents were generally adults (people aged 18 years and above), which cut across all demographics.

We used then used R Studio Statistical Program (The R Foundation, 2021), with the FitMeasures function from the lavaan package and also the haven package.

For proof of concept and prototypical purposes, we created an online shop at www.filteredkenya.co.ke, which was an aggregation shop where many affiliates were selling through. The affiliates represent the represent natural online vendors. We used the web scrapping technique and augment it with a manual going through the affiliate website before affiliate approval to harvest the states of affiliates' websites in terms of indicators of trust or ethics as per the results of our study. We used the scrapped data together with the derived SEM model from our study to predict online vendor's trust scores as a trust parameter for the recommendation algorithm. We also profiled the online shoppers as per their characteristics such as age and other personal preferences and used the information to classify the online shopper into nearest neighbors in terms of similarity. This classification then helped us in Common Filtering Recommendation Algorithm.

To incorporate our trust parameter into the recommender system algorithm, we rely on the method that has been tested and worked as per the work of (Yin, Wang, & Park, 2017). The only difference is that for our case, we used the following steps to derive our trust parameter.

The algorithm *steps to derive Trust*

Step 1: Get the loadings between the observed variables and the intermediary constructs that the variables measure.

Step 2: For each observed variable on the model, get the percentage weight (w_o) with which it contributes to the intermediary construct that it measures by taking the quotient of its loading divided by the sum of all loadings of the indicators on the same intermediary construct.

Step 3: Compute the degree to which each intermediary construct is present (p_c) in a site by checking the presence of indicators on-site and summing the weights of all present indicators that have been computed in step 2.

Step 4: For each intermediary construct on the model, get the percentage weight (w_c) with which it contributes to the final trust by taking the quotient of its loading divided by the sum of all loadings of the intermediary constructs onto the final trust.

Step 5: Compute the degree with which the final trust degree exists by summing the products of intermediary construct's degree of presence (p_c) and percentage weight (w_c) with which it contributes to the final trust for all the intermediary constructs.

IV. RESULTS

We carried out a confirmatory factor analysis test on our second study data. We got an overall trust model, as shown in figure 3, which shows the pictorial representation of the overall trust model for online retailers from the consumer perspective. In this model, we have two layers in the hierarchy. The first layer was describing the loadings of the observed variables on to the intermediary constructs that they measure, and the second layer was describing the loadings of the intermediary constructs on to the final trust parameter.
The factor loadings are shown alongside the factors in figure 1; however, the indicator loadings to their corresponding factors, which in figure 3, are demarcated by Y1-Y18, are shown in tables 1 to 3.

Table 1. Reliability indicators and loadings

Indicator	Loading
Y_{10}: The price shown on the site is the actual amount billed	0.72
Y_{11}: You get what you ordered from this site	0.88
Y_{12}: The products I looked at were available	0.70
Y_{13}: Promises to do something by a certain time; they do it.	0.71

Table 2. Security indicators and loadings

Indicator	Loading
Y_1: Site's Security Policy easy to understand	0.81
Y_2: Site's Terms and Conditions are displayed:	0.80
Y_3: Site owner's background information displayed:	0.78
Y_4: The site offers secure payment methods	0.83
Y_5: You can confirm the details of the transaction before paying	0.76
Y_6: The site has adequate security features	0.82
Y_7: The site clearly explains how user information is used	0.78
Y_8: Information regarding the privacy policy is clearly presented	0.74
Y_9: Only the personal information necessary for the transaction to be completed needs to be provided	0.70

Table 3. Confidence indicators and loadings

Indicator	Loading
Y_{14}: The site exaggerates the benefits and characteristics of its offerings	0.7
Y_{15}: The site is not entirely truthful about its offerings	0.73
Y_{16}: The site uses misleading tactics to convince consumers to buy its products	0.81
Y_{17}: This site takes advantage of less experienced consumers to make the purchase:	0.78
Y_{18}: This site attempts to persuade you to buy things that you do not need	0.70

Table 4. Fit statistics

Measure	Name	Cut off for good fit	Finding	Passed
X^2	Chi-Square	p-value > 0.005		OK
RMSEA	Root Mean Square Error of Approximation	RMSEA < 0.08	0.06	OK
CFI	Comparative Fit Index	CFI ≥.90	0.93	OK
(S)RMR	(Standardized) Root Mean Square Residual	SRMR <0.08	0.06	OK
(N)NFI TLI	(Non) Normed-Fit Index Tucker Lewis index	NFI ≥ 0.95 NNFI ≥ 0.95	0.96	OK

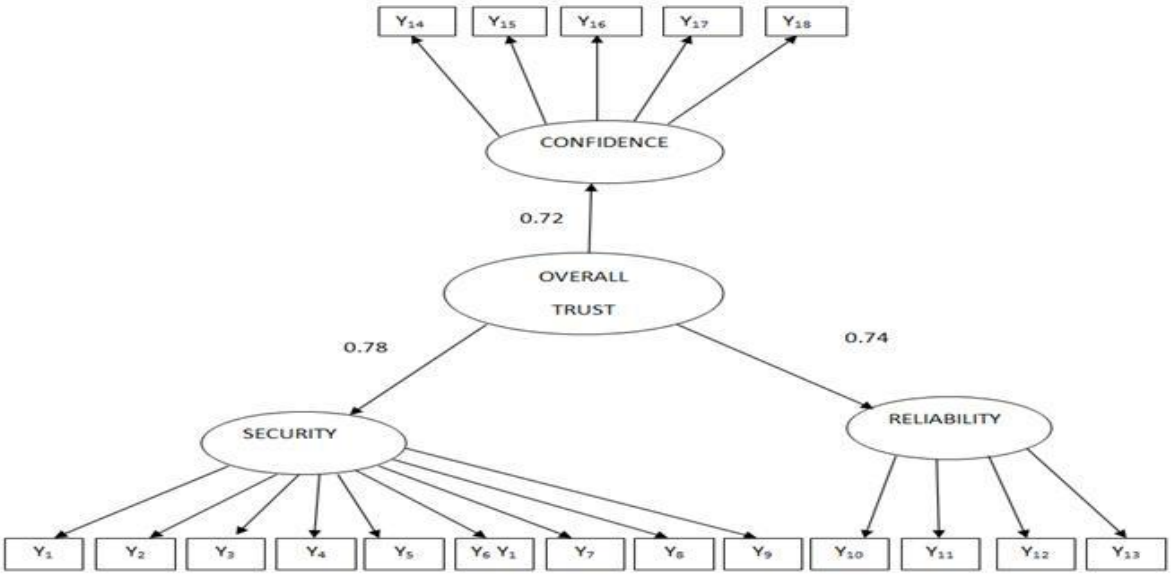

Fig. 1 Two layer trust model

Table 5. Data reliability

Measure	Cut off for reliable data	Finding	Passed
Convergent validity	> 0.5	Security: 0.68 Trust: 0.67 Reliability: 0.72	OK OK OK
Discriminant validity	More than variables correlation	OK	OK
Cronbach's / Coefficient Alpha	> 0.7	0.78	OK

Table 6. Prototype empritcal data – root mean square algorithm accuracy data

Neighbors	5	10	15	20	25
CFRA	0.9472	0.9408	0.9362	0.9307	0.9266
CFRAT	0.9406	0.9363	0.9302	0.9248	0.9187

Table 7. Prototype empirical data – mean absolute error algorithm accuracy data

Neighbors	5	10	15	20	25
CFRA	0.9721	0.96464	0.9608	0.9509	0.9482
CFRAT	0.9583	0.9574	0.9456	0.9402	0.9311

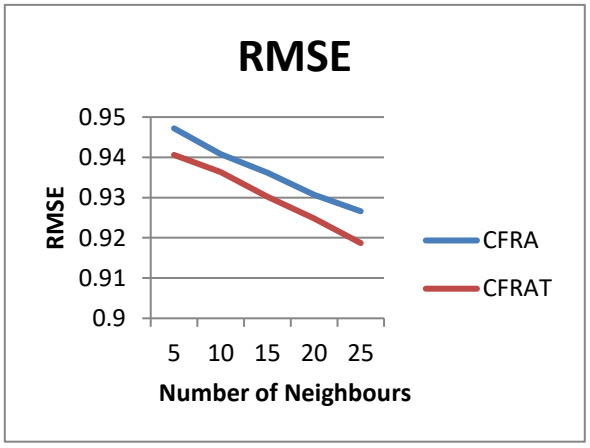

Fig. 2 Algorithm prototype empirical results RMSE curve

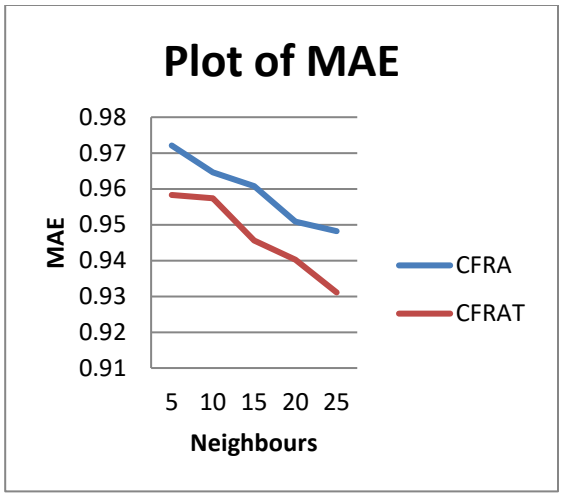

Fig. 3 Prototype empirical results MAE curve

V. DISCUSSION

From the ongoing discussion, we can see that we carried out research on how to model trust for online retailers using structural equation modeling statistical technique. We then used this modeled trust, shown in figure 1, as a new parameter for the recommender system algorithm.

The effect of our new trust parameter on the recommender system algorithm is, to a large extent, comparable with the results of (Yin, Wang, & Park, 2017). This confirms that our method of computing trust, even though novel, is also as effective as what has been documented in the literature by previous studies. In (Yin, Wang, & Park, 2017), the trust parameter was acquired by asking users to directly declare their trust levels against other users. The disadvantage of this method is that it is cumbersome and reactive since the users only get to know the trustworthiness of another user or vendor after a few successful attacks, but we appreciate the work since its research served as a good foundational basis to open ways for our research. The reduced error as shown on the graphs means that the accuracy of the recommender system increases, and in both cases, it is evident that in the cases where trust is incorporated into the algorithm (CFRAT), the level of error is even lower than in the cases where trust has not been incorporated (CFRA) meaning the improvement in accuracy of the recommender system

We have also presented our fit statistics in table 4 to confirm that our model is scientifically fit and data reliability parameters in table 5, which are all above cut-off points for reliable data.

VI. CONCLUSION AND FURTHER RESEARCH

We have developed and validated a scale that will be used to computationally estimate the trustworthiness of an online retailer and filter out potentially fraudulent services from a possible output of a recommender system. This will improve the user experience in online services since users will not only be protected from potential fraud but also feel confident while shopping online, knowing at the back of their mind that whatever recommender systems output to them is safe for their consumption.

Having satisfactorily and scientifically modeled trust in sociology for automated computational use and tested it on a prototypical environment as a new parameter from the perspective of prediction accuracy, we are going on with this research so as to also scientifically test the impact of this new recommender system parameter on other dimensions of recommender system such as time, Scalability, Adaptivity, Privacy, Robustness, Risk, Utility, Diversity, Serendipity, Novelty, Trust, Confidence, Coverage. These dimensions of the recommender system are described in (Ricci, Rokach, & Shapira, 2011)

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