

inability to validate the model on a real OSN platform by verifying the resulted clone profiles was another main limitation of the work.

D. Future Improvements

As future improvements to this work, the model can be tested with more than ten attributes to identify the relationships between different attributes and clone profiles. Further cross-platform detections where the clones are in a different platform, using string matching algorithms to match the actual text of a name when non anonymized features are given, can improve this work. Also, this research study's main future interest is to build a model to detect the actual person behind this clone who created the clone profile by analyzing the behavioral patterns of profiles in OSN.

IV. CONCLUSION

Due to the popularity of the platform and the simplicity of making profiles, the threat of creating clone profiles has been increased on Facebook. With this attack, users' personal information can be misused and can cause damages to their good reputation. This paper introduces a model with three primary stages to detect these clone profiles on Facebook, wherein at each stage, the amount of computation to be done was reduced by filtering profiles in each of the stages. This method was a simple but more effective method that also showed a higher precision. Furthermore, as most of the calculations are done considering the dataset's distribution, this model can be easily adjusted to a different dataset by only finding values for few parameters.

REFERENCES

- [1] Statista, "Social Media Statistics & Facts," 2017. [Online]. Available: <https://www.statista.com/topics/1164/social-networks/>. [Accessed: 30-Oct-2017].
- [2] WordStream, "40 Essential Social Media Marketing Statistics for 2017," 2017. [Online]. Available: <http://www.wordstream.com/blog/ws/2017/01/05/social-media-marketing-statistics>. [Accessed: 10-Nov-2017].
- [3] F. Rizi, M. Khayyambashi, and M. Kharaji, "A New Approach for Finding Cloned Profiles in Online Social Networks," *Int. J. Netw. Secur.*, vol. 6, no. April, pp. 25–37, 2014.
- [4] L. Jin, H. Takabi, and J. B. D. Joshi, "Towards active detection of identity clone attacks on online social networks," *Proc. first ACM Conf. Data Appl. Secur. Priv. - CODASPY '11*, p. 27, 2011.
- [5] P. Dewan, S. Bagroy, and P. Kumaraguru, "Hiding in Plain Sight: Characterizing and Detecting Malicious Facebook Pages," pp. 193–196, 2016.
- [6] K. Krombholz, D. Merkl, and E. Weippl, "Fake identities in social media: A case study on the sustainability of the Facebook business model," *J. Serv. Sci. Res.*, vol. 4, no. 2, pp. 175–212, 2012.
- [7] G. A. Kamhoua et al., "Preventing Colluding Identity Clone Attacks in Online Social Networks," in *2017 IEEE 37th International Conference on Distributed Computing Systems Workshops (ICDCSW)*, 2017, pp. 187–192.
- [8] M. A. Devmane and N. K. Rana, "Detection and prevention of profile cloning in online social networks," *Int. Conf. Recent Adv. Innov. Eng. ICRAIE 2014*, pp. 9–13, 2014.
- [9] M. Torky, A. Meligy, and H. Ibrahim, "Recognizing fake identities in online social networks based on a finite automaton approach," *2016 12th Int. Comput. Eng. Conf. ICENCO 2016 Boundless Smart Soc.*, pp. 1–7, 2017.
- [10] M. Egele, C. Kruegel, and G. Vigna, "COMPA: Detecting Compromised Accounts on Social Networks."
- [11] P. Bródka, M. Sobas, and H. Johnson, "Profile cloning detection in social networks," *Proc. - 2014 Eur. Netw. Intell. Conf. ENIC 2014*, pp. 63–68, 2014.
- [12] A. Malhotra, L. Totti, W. Meira, P. Kumaraguru, and V. Almeida, "Studying user footprints in different online social networks," *Proc. 2012 IEEE/ACM Int. Conf. Adv. Soc. Networks Anal. Mining, ASONAM 2012*, pp. 1065–1070, 2013.
- [13] R. N. Reddy and N. Kumar, "Automatic detection of fake profiles in online social networks," 2012.
- [14] N. Kumar and R. N. Reddy, "Automatic Detection of Fake Profiles in Online Social Networks," *National Institute of Technology Rourkela Rourkela-769 008, Orissa, India*, 2012.
- [15] M. Kharaji and F. Rizi, "An IAC Approach for Detecting Profile Cloning in Online Social Networks," *Int. J. Netw. Secur. Its Appl.*, vol. 6, no. 1, pp. 75–90, 2014.
- [16] M. Zabielski, R. Kasprzyk, Z. Tarapata, and K. Szkółka, "Methods of Profile Cloning Detection in Online Social Networks," *MATEC Web Conf.*, vol. 76, 2016.
- [17] G. Kontaxis, I. Polakis, S. Ioannidis, and E. P. Markatos, "Detecting social network profile cloning," *2011 IEEE Int. Conf. Pervasive Comput. Commun. Work. PERCOM Work. 2011*, pp. 295–300, 2011.
- [18] M. R. Khayyambashi and F. S. Rizi, "An approach for detecting profile cloning in online social networks," *2013 7th International Conf. E-Commerce Dev. Ctries. With Focus e-Security, ECDC 2013*, pp. 1–12, 2013.
- [19] F. S. Rizi and M. R. Khayyambashi, "Profile Cloning in Online Social Networks," *Int. J. Comput. Sci. Inf. Secur.*, vol. 11, no. 8, pp. 82–86, 2013.
- [20] Q. Cao, X. Yang, J. Yu, and C. Palow, "Uncovering Large Groups of Active Malicious Accounts in Online Social Networks," *Proc. 2014 ACM SIGSAC Conf. Comput. Commun. Secur. - CCS '14*, pp. 477–488, 2014.
- [21] J. Lescovec, "Stanford University - Data Repository," 2012. [Online]. Available: <https://snap.stanford.edu/data/egonets-Facebook.html>. [Accessed: 10-May-2018].
- [22] S. Mazhari, S. M. Fakhrahmad, and H. Sadeghbeygi, "A user-profile-based friendship recommendation solution in social networks," *J. Inf. Sci.*, vol. 41, no. 3, pp. 284–295, 2015.
- [23] D. Dave, N. Mishra, and S. Sharma, "Detection Techniques of Clone Attack on Online Social Networks: Survey and Analysis," pp. 179–186.
- [24] Facebook, "Finding Friends and people you may know," 2018. [Online]. Available: www.facebook.com/help/www/336320879782850. [Accessed: 10-Dec-2018].
- [25] V. A and R. I. M. Dunbar, "Evolutionary Dynamics in Twitter Ego Networks," 2015. [Online]. Available: <https://www.sciencedirect.com/topics/computer-science/jaccard-coefficient>. [Accessed: 23-Sep-2018].
- [26] "Evaluation of clustering - Stanford NLP Group," 2009. [Online]. Available: <https://nlp.stanford.edu/IR-book/html/htmledition/evaluation-of-clustering-1.html>. [Accessed: 03-Jan-2019].