

**AGE ESTIMATION UNTUK INTELLIGENT ADVERTISING PADA
POSTER DIGITAL MENGGUNAKAN CONVOLUTIONAL NEURAL
NETWORK**

SKRIPSI

Diajukan untuk Memenuhi Bagian dari
Syarat Memperoleh Gelar Sarjana Komputer
Pada Departemen Pendidikan Ilmu Komputer
Program Studi Ilmu Komputer



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AGE ESTIMATION UNTUK INTELLIGENT ADVERTISING PADA POSTER
DIGITAL MENGGUNAKAN CONVOLUTIONAL NEURAL NETWORK

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Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar
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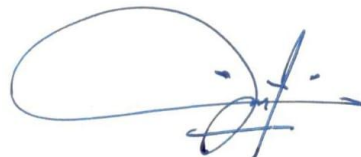
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PERNYATAAN

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Bandung, Agustus 2020
Yang membuat pernyataan,

Galih Abdul Muhyi

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Pada kesempatan ini penulis menghaturkan terima kasih sebesar-besarnya kepada pihak-pihak yang berperan serta baik secara langsung maupun tidak langsung dalam penyelesaian skripsi ini. Seperti kata pepatah, tidak ada gading yang tak retak sehingga penulisan ini bisa disebut jauh dari kata sempurna. Oleh karena itu, penulis sangat mengharapkan saran maupun kritik yang membangun agar tidak terjadi kesalahan yang sama di kemudian hari dan dapat meningkatkan kualitas ke tahap yang lebih baik.

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AGE ESTIMATION UNTUK INTELLIGENT ADVERTISING PADA POSTER DIGITAL MENGGUNAKAN CONVOLUTIONAL NEURAL NETWORK

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ABSTRAK

Sebagai bagian dari intelligent advertising, age estimation digunakan untuk menyesuaikan iklan dari hasil estimasi usia audience. Age estimation (AE) dapat dibangun menggunakan deep learning menggunakan ConvNet dengan kendala seperti data training wajah usia tua yang sedikit, ketidak seimbangan dataset di dalamnya, serta membutuhkan jumlah data yang besar. Salah satu solusi dari permasalahan ini adalah melakukan data augmentasi menggunakan model generatif ACGAN untuk melakukan generate gambar sesuai dengan kelas. Intelligent advertising pada poster digital hanya disimulasikan pada komputer. Simulasi intelligent advertising berfungsi dengan baik terlepas dari terbatasnya iklan dan tidak konsistennya hasil estimasi usia. Hasil dari penggunaan model generatif ACGAN untuk data augmentation berhasil meningkatkan performa hasil pada model AE terlepas dari rendahnya skor IS dan FID serta kualitas gambar yang dihasilkan. Hasil data augmentation lebih terlihat pada model B dengan peningkatan akurasi cumulative score sebesar 4,8% dan skor MAE sebesar 1,297.

Kata Kunci: Intelligent Advertising, Age Estimation, ACGAN, Convolutional Neural Network.

AGE ESTIMATION FOR INTELLIGENT ADVERTISING ON DIGITAL SIGNAGE USING CONVOLUTIONAL NEURAL NETWORK

*Arranged by
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ABSTRACT

As part of intelligent advertising, age estimation is used to adjust advertisement from the estimated age of the audience. Age estimation (AE) can be built from deep learning using ConvNet with limitation such as low number of old age facial training data, dataset imbalances, and it requires a large amount of data. One of the solution to this problem is to perform data augmentation using ACGAN generative models to generate images according to the class. Intelligent advertising on digital posters is only simulated on computers. Intelligent advertising simulations work well regardless of limited ads availability and inconsistent age estimation results. The results of ACGAN generative models for data augmentation managed to improve the performance of results on AE models regardless of low IS and FID scores and low quality image result. Data augmentation results were more noticeable in model B with an increase in cumulative score accuracy of 4.8% and MAE score of 1,297

Keywords: Intelligent Advertising, Age Estimation, ACGAN, Convolutional Neural Network.

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DAFTAR PUSTAKA

- Abraham, R. E., & Kennedy, M. R. (2018). Intelligent digital signage system based on gender identification. *Intelligent Embedded Systems*, 492, 251–262. https://doi.org/10.1007/978-981-10-8575-8_25
- Ahmed, M., & Viriri, S. (2017). Age Estimation using Facial Images : A Survey of the State-of-the-art. *2017 Sudan Conference on Computer Science and Information Technology (SCCSIT)*.
- Akbari, M. A., Takahashi, H., & Nakajima, M. (2005). Discerning advisor: An intelligent advertising system for clothes considering skin color. *Proceedings - 2005 International Conference on Cyberworlds, CW 2005, 2005*, 202–209. <https://doi.org/10.1109/CW.2005.40>
- Akhras, G. (2000). Smart materials and smart systems for the future. *Canadian Military Journal*, 1(3), 25–31.
- Al-Shannaq, A. S., & Elrefaei, L. A. (2019). Comprehensive Analysis of the Literature for Age Estimation from Facial Images. *IEEE Access*, 7, 93229–93249. <https://doi.org/10.1109/ACCESS.2019.2927825>
- Aloysius, N., & Geetha, M. (2018). A review on deep convolutional neural networks. *Proceedings of the 2017 IEEE International Conference on Communication and Signal Processing, ICCSP 2017, 2018-Janua*, 588–592. <https://doi.org/10.1109/ICCSP.2017.8286426>
- Antoniou, A., Storkey, A., & Edwards, H. (2017). *Data Augmentation Generative Adversarial Network*. <https://doi.org/10.2139/ssrn.3349576>
- Arjovsky, M., Chintala, S., & Bottou, L. (2017). *Wasserstein GAN*. <https://arxiv.org/abs/1701.07875>

- Barratt, S., & Sharma, R. (2018). *A Note on the Inception Score*.
<http://arxiv.org/abs/1801.01973>
- Batagelj, B., Ravnik, R., & Solina, F. (2008). Computer Vision and Digital Signage. *Tenth International Conference on Multimodal Interfaces 2008, September 2015*, 1–4.
- Batista, G. E. A. P. A., Prati, R. C., & Monard, M. C. (2004). A study of the behavior of several methods for balancing machine learning training data. *ACM SIGKDD Explorations Newsletter*, 6(1), 20–29.
<https://doi.org/10.1145/1007730.1007735>
- Bauer, C., Garaus, M., Strauss, C., & Wagner, U. (2018). Research directions for digital signage systems in retail. *Procedia Computer Science*, 141(November), 503–506. <https://doi.org/10.1016/j.procs.2018.10.135>
- Bejiga, M. B., & Melgani, F. (2018). GAN-Based Domain Adaptation For Object Classification. *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium*, 1264–1267.
- Bekhouche, S. E., Ouafi, A., Benlamoudi, A., Taleb-Ahmed, A., & Hadid, A. (2015). Facial age estimation and gender classification using multi level local phase quantization. *3rd International Conference on Control, Engineering and Information Technology, CEIT 2015, September*.
<https://doi.org/10.1109/CEIT.2015.7233141>
- Borji, A. (2019). Pros and cons of GAN evaluation measures. *Computer Vision and Image Understanding*, 179, 41–65. <https://doi.org/10.1016/j.cviu.2018.10.009>
- Bowles, C., Chen, L., Guerrero, R., Bentley, P., Hammers, A., Dickie, D. A., & Vald, M. (2018). *GAN Augmentation: Augmenting Training Data using Generative Adversarial Networks*. <https://arxiv.org/abs/1810.10863>

- Burger, W., & Burge, M. J. (2016). Digital Image Processing: An Algorithmic Introduction Using Java Second Edition. In *Springer* (Vol. 24, Issue 11). Springer. <https://doi.org/10.1007/978-1-4471-6684-9>
- Cai, L., Huang, L., & Liu, C. (2016). Age estimation based on improved discriminative Gaussian process latent variable model. *Multimedia Tools and Applications*, 75, 11977–11994. <https://doi.org/https://doi.org/10.1007/s11042-015-2668-4>
- Cao, C., Liu, F., Tan, H., Song, D., Shu, W., Li, W., Zhou, Y., Bo, X., & Xie, Z. (2018). Deep Learning and Its Applications in Biomedicine. *Genomics, Proteomics and Bioinformatics*, 16(1), 17–32. <https://doi.org/10.1016/j.gpb.2017.07.003>
- Cao, X., Zhao, X., & Zhao, Q. (2018). Tensoring Generatifve Adversarial Nets. *2018 IEEE International Conference on Consumer Electronics - Asia (ICCE-Asia)*, 206–212.
- Cao, Y. J., Jia, L. L., Chen, Y. X., Lin, N., Yang, C., Zhang, B., Liu, Z., Li, X. X., & Dai, H. H. (2019). Recent Advances of Generative Adversarial Networks in Computer Vision. *IEEE Access*, 7(c), 14985–15006. <https://doi.org/10.1109/ACCESS.2018.2886814>
- Chen, H., Engkvist, O., Wang, Y., Olivecrona, M., & Blaschke, T. (2018). The Rise Of Deep Learning In Drug Discovery. *Drug Discovery Today*, 23(6), 1241–1250. <https://doi.org/10.1016/j.drudis.2018.01.039>
- Chen, L., Fan, C., Yang, H., Hu, S., Zou, L., & Deng, D. (2018). Face age classification based on a deep hybrid model. *Signal, Image and Video Processing*, 12(8), 1531–1539. <https://doi.org/10.1007/s11760-018-1309-6>

- Chen, S., Zhang, C., & Dong, M. (2018). Deep Age Estimation: From Classification to Ranking. *IEEE Transactions on Multimedia*, 20(8), 2209–2222. <https://doi.org/https://doi.org/10.1109/TMM.2017.2786869>
- Chen, X., Duan, Y., Houthoofd, R., Schulman, J., Sutskever, I., & Abbeel, P. (2016). InfoGAN: Interpretable Representation Learning by Information Maximizing Generative Adversarial Nets. In D. D. Lee, M. Sugiyama, U. V Luxburg, I. Guyon, & R. Garnett (Eds.), *Advances in Neural Information Processing Systems* 29 (pp. 2172–2180). Curran Associates, Inc. <http://papers.nips.cc/paper/6399-infogan-interpretable-representation-learning-by-information-maximizing-generative-adversarial-nets.pdf>
- Cheng, F.-Y., Chang, C.-J., & Jong, G.-J. (2013). Digital Interactive Kanban Advertisement System Using Face Recognition Methodology. *Computational Water, Energy, and Environmental Engineering*, 02(03), 26–30. <https://doi.org/10.4236/cweee.2013.23b005>
- Cheng, J., Li, Y., Wang, J., Yu, L., & Wang, S. (2019). Exploiting effective facial patches for robust gender recognition. *Tsinghua Science and Technology*, 24(3), 333–345. <https://doi.org/10.26599/TST.2018.9010090>
- Chiaroni, F., Rahal, M. C., Hueber, N., & Dufaux, F. (2018). Learning with a generative adversarial network from a positive unlabeled dataset for image classification. *Proceedings - International Conference on Image Processing, ICIP*, 1368–1372. <https://doi.org/10.1109/ICIP.2018.8451831>
- Cho, J. H., Jang, D. W., Park, R. H., Wang, D.-W., & Park, R. H. (2018). Age category estimation using matching convolutional neural network. *2018 IEEE International Conference on Consumer Electronics (ICCE), 2018-Janua*, 1–8. <https://doi.org/10.1109/ICCE.2018.8326310>
- Cireşan, D. C., Meier, U., Gambardella, L. M., & Schmidhuber, J. (2010). Deep,

- Big, Simple Neural Nets for Handwritten Digit Recognition. *Neural Computation*, 22(12), 3207–3220. https://doi.org/10.1162/NECO_a_00052
- Dash, A., Gamboa, J. C. B., Ahmed, S., Liwicki, M., & Afzal, M. Z. (2017). *TAC-GAN - Text Conditioned Auxiliary Classifier Generative Adversarial Network*. <http://arxiv.org/abs/1703.06412>
- Dean, J., Corrado, G. S., Monga, R., Chen, K., Matthieu, D., Le, Q. V., Mao, M. Z., Ranzato, M., Senior, A., Tucker, P., Yang, K., & Y. Ng, A. (2012). Large Scale Distributed Deep Networks. *Advances in Neural Information Processing Systems*, 1223–1231.
- Denton, E., Gross, S., & Fergus, R. (2016). *Semi-Supervised Learning with Context-Conditional Generative Adversarial Networks*. 1–10. <http://arxiv.org/abs/1611.06430>
- Dong, Y., Liu, Y., & Lian, S. (2016). Automatic age estimation based on deep learning algorithm. *Neurocomputing*, 187, 4–10. <https://doi.org/10.1016/j.neucom.2015.09.115>
- Duan, M., Li, K., & Li, K. (2018). An ensemble CNN2ELM for age estimation. *IEEE Transactions on Information Forensics and Security*, 13(3), 758–772. <https://doi.org/10.1109/TIFS.2017.2766583>
- Duchi, J. C., Hazan, E., & Singer, Y. (2011). Adaptive Subgradient Methods for Online Learning and Stochastic Optimization. *Journal of Machine Learning Research*, 12, 5442–5444. <https://doi.org/10.1109/CDC.2012.6426698>
- Dumoulin, V., & Visin, F. (2016). *A guide to convolution arithmetic for deep learning*. 1–31. <http://arxiv.org/abs/1603.07285>
- Durugkar, I. P., Gemp, I., & Mahadevan, S. (2016). Generative Multi-Adversarial

Networks. *CoRR*, *abs/1611.0*. <http://arxiv.org/abs/1611.01673>

Eidinger, E., Enbar, R., & Hassner, T. (2014). Age and Gender Estimation of Unfiltered Faces. *IEEE Transactions on Information Forensics and Security*, 9(12), 2170–2179. <https://doi.org/https://doi.org/10.1109/TIFS.2014.2359646>

Farinella, G. M., Farioli, G., Battiato, S., Leonardi, S., & Gallo, S. (2014). Face Re-Identification For Digital Signage Applications. *International Workshop on Video Analytics for Audience Measurement in Retail and Digital Signage*, 8811(April 2016), 40–52. <https://doi.org/10.1007/978-3-319-12811-5>

Fu, Y., Guo, G., & Huang, T. S. (2010). Age synthesis and estimation via faces: A survey. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 32(11), 1955–1976. <https://doi.org/10.1109/TPAMI.2010.36>

Fukushima, K. (1988). Neocognitron: A hierarchical neural network capable of visual pattern recognition. *Neural Networks*, 1(2), 119–130. [https://doi.org/10.1016/0893-6080\(88\)90014-7](https://doi.org/10.1016/0893-6080(88)90014-7)

Gao, F., & Ai, H. (2009). Face age classification on consumer images with gabor feature and fuzzy LDA method. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 5558 LNCS, 132–141. https://doi.org/10.1007/978-3-642-01793-3_14

Geng, X., Yin, C., & Zhou, Z. H. (2013). Facial age estimation by learning from label distributions. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 35(10), 2401–2412. <https://doi.org/10.1109/TPAMI.2013.51>

Geng, X., Zhou, Z. H., & Smith-Miles, K. (2007). Automatic age estimation based on facial aging patterns. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 29(12), 2234–2240. <https://doi.org/10.1109/TPAMI.2007.70733>

- Glorot, X., Bordes, A., & Bengio, Y. (2011). Deep Sparse Rectifier Neural Networks. *Proceedings of the Fourteenth International Conference on Artificial Intelligence and Statistics*, 315–323.
- Gohatre, U. B., Chaudhari, M. V. D., & Rane, D. K. P. (2015). Rasp-Pi based Remote Controlled Smart Advertising of Still and Moving Images. *International Journal Of Engineering And Computer Science*, October. <https://doi.org/10.18535/ijecs/v4i9.67>
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press. <http://www.deeplearningbook.org/>
- Goodfellow, I. J., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A., & Bengio, Y. (2014). Generative adversarial nets. *Advances in Neural Information Processing Systems*, 3(January), 2672–2680.
- Guo, G., Fu, Y., Dyer, C. R., & Huang, T. S. (2008). Image-Based Human Age Estimation by Manifold Learning and Locally Adjusted Robust Regression. *IEEE Transactions on Image Processing*, 17(7), 1178–1188. <https://doi.org/10.1109/TIP.2008.924280>
- Gurpinar, F., Kaya, H., Dibeklioglu, H., & Salah, A. A. (2016). Kernel ELM and CNN Based Facial Age Estimation. *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Workshops*, 80–86. <https://doi.org/10.1109/CVPRW.2016.103>
- Heusel, M., Ramsauer, H., Unterthiner, T., Nessler, B., & Hochreiter, S. (2017). GANs Trained by a Two Time-Scale Update Rule Converge to a Local Nash Equilibrium. In I. Guyon, U. V Luxburg, S. Bengio, H. Wallach, R. Fergus, S. Vishwanathan, & R. Garnett (Eds.), *Advances in Neural Information Processing Systems 30* (pp. 6626–6637). Curran Associates, Inc.

<http://papers.nips.cc/paper/7240-gans-trained-by-a-two-time-scale-update-rule-converge-to-a-local-nash-equilibrium.pdf>

Hinton, G. E., Osindero, S., & Teh, Y.-W. (2006). A Fast Learning Algorithm for Deep Belief Nets. *Neural Computation*, 18(7), 1527–1554. <https://doi.org/10.1162/neco.2006.18.7.1527>

Hu, Z., Wen, Y., Wang, J., Wang, M., Hong, R., & Yan, S. (2017). Facial Age Estimation With Age Difference. *IEEE Transactions on Image Processing*, 26(7), 3087–3097. <https://doi.org/https://doi.org/10.1109/TIP.2016.2633868>

Hubel, D. H., & Wiesel, T. N. (1962). Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. *The Journal of Physiology*, 160(1), 106–154. <https://doi.org/10.1113/jphysiol.1962.sp006837>

Ioffe, S., & Szegedy, C. (2015). Batch normalization: Accelerating deep network training by reducing internal covariate shift. *32nd International Conference on Machine Learning, ICML 2015*, 1, 448–456.

Israel, S. A., Goldstein, J. H., Klein, J. S., Talamonti, J., Tanner, F., Zabel, S., Sallee, P. A., & McCoy, L. (2018). Generative adversarial networks for classification. *Proceedings - Applied Imagery Pattern Recognition Workshop, 2017-October*, 1–4. <https://doi.org/10.1109/AIPR.2017.8457952>

Jaitley, N., & Hinton, G. (2013). Vocal tract length perturbation (VTLP) improves speech recognition. *Proc. ICML Workshop on Deep Learning for Audio, Speech and Language*.

Jarrett, K., Kavukcuoglu, K., Ranzato, M., & Lecun, Y. (2009). What is the best multi-stage architecture for object recognition? *2009 IEEE 12th International Conference on Computer Vision*, 2146–2153. <https://doi.org/10.1109/ICCV.2009.5459469>

- Khan, J., Khusro, S., & Jabeen, F. (2014). Digital Signage Systems: Review of Past, Present & Future. *Proceedings of the 3rd International Conference on Computer Science & Computational Mathematics (ICCSCM 2014)*, May, 196–208.
- Khan, S., Rahmani, H., Shah, S. A. A., & Bennamoun, M. (2018). A Guide to Convolutional Neural Networks for Computer Vision. In *Synthesis Lectures on Computer Vision* (Vol. 8, Issue 1). Morgan & Claypool Publishers. <https://doi.org/10.2200/s00822ed1v01y201712cov015>
- Kingma, D. P., & Ba, J. L. (2015). Adam: A method for stochastic optimization. *3rd International Conference on Learning Representations, ICLR 2015 - Conference Track Proceedings*, 1–15.
- Kok, C.-W., & Tam, W.-S. (2018). Digital Image Interpolation in Matlab. In *Digital image interpolation in Matlab First Edition*. Wiley-IEEE Press.
- Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet Classification with Deep Convolutional Neural Networks. In F. Pereira, C. J. C. Burges, L. Bottou, & K. Q. Weinberger (Eds.), *Advances in Neural Information Processing Systems* 25 (pp. 1097–1105). Curran Associates, Inc. <http://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networ>
- Kullback, S., & Leibler, R. A. (1951). On Information and Sufficiency. *The Annals of Mathematical Statistics*, 22(1), 79–86. <http://www.jstor.org/stable/2236703>
- Kwon, Y. H., & Lobo, N. da V. (1999). Age classification from Facial Images. *Computer Vision and Image Understanding*, 74(1), 1–21. <https://doi.org/10.1006/cviu.1997.0549>
- Lecun, Y., Boser, B., Denker, J. S., Henderson, D., Howard, R. E., Hubbard, W., &

- Jackel, L. D. (1989). Backpropagation applied to digit recognition. In *Neural computation* (Vol. 1, Issue 4, pp. 541–551).
- Lecun, Y., Bottou, L., Bengio, Y., & Haffner, P. (1998). Gradient-Based Learning Applied to Document Recognition. *Proceedings of the IEEE* 86, 86(11), 2278–2324. <http://ieeexplore.ieee.org/document/726791/#full-text-section>
- Lee, S.-H., Sohn, M.-K., & Kim, H. (2015). Implementation of age and gender recognition system for intelligent digital signage. *Eighth International Conference on Machine Vision (ICMV 2015)*, 9875(Icmv), 98750I. <https://doi.org/10.1117/12.2228520>
- Lee, S. H., Hosseini, S., Kwon, H. J., Moon, J., Koo, H. Il, Cho, N. I., Hyuk, J. K., Moon, J., Koo, H. Il, & Cho, N. I. (2018). Age and gender estimation using deep residual learning network. *2018 International Workshop on Advanced Image Technology (IWAIT)*, 1–3. <https://doi.org/10.1109/IWAIT.2018.8369763>
- Levi, G., & Hassner, T. (2015). Age And Gender Classification Using Convolutional Neural Networks. *IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops*, 34–42. <https://doi.org/10.1109/AFGR.2008.4813314>
- Li, K., Xing, J., Hu, W., & Maybank, S. J. (2017). D2C: Deep cumulatively and comparatively learning for human age estimation. *Pattern Recognition*, 66, 99–105. <https://doi.org/https://doi.org/10.1016/j.patcog.2017.01.007>
- Liu, H., Lu, J., Feng, J., & Zhou, J. (2017). Group-aware deep feature learning for facial age estimation. *Pattern Recognition*, 66, 82–94. <https://doi.org/https://doi.org/10.1016/j.patcog.2016.10.026>
- Lucic, M., Kurach, K., Michalski, M., Bousquet, O., & Gelly, S. (2018). Are GANs

Created Equal? A Large-Scale Study. In S. Bengio, H. Wallach, H. Larochelle, K. Grauman, N. Cesa-Bianchi, & R. Garnett (Eds.), *Advances in Neural Information Processing Systems 31* (pp. 700–709). Curran Associates, Inc. <http://papers.nips.cc/paper/7350-are-gans-created-equal-a-large-scale-study>

Maas, A. L., Hannun, A. Y., & Ng, A. Y. (2013). Rectifier nonlinearities improve neural network acoustic models. *ICML Workshop on Deep Learning for Audio, Speech and Language Processing*, 28.

Mao, X., Li, Q., Xie, H., Lau, R. Y. K., Wang, Z., & Smolley, S. P. (2017). Least Squares Generative Adversarial Networks. *Proceedings of the IEEE International Conference on Computer Vision, 2017-October*, 2813–2821. <https://doi.org/10.1109/ICCV.2017.304>

McCarthy, J. F., Farnham, S. D., Patel, Y., Ahuja, S., Norman, D., Hazlewood, W. R., & Lind, J. (2009). *Supporting community in third places with situated social software*. January, 225. <https://doi.org/10.1145/1556460.1556493>

McDonald, D. W., McCarthy, J. F., Soroczak, S., Nguyen, D. H., & Rashid, A. M. (2008). Proactive displays: Supporting awareness in fluid social environments. *ACM Transactions on Computer-Human Interaction*, 14(4). <https://doi.org/10.1145/1314683.1314684>

Miyato, T., Kataoka, T., Koyama, M., & Yoshida, Y. (2018). Spectral Normalization for Generative Adversarial Networks. *CoRR*, abs/1802.0. <http://arxiv.org/abs/1802.05957>

Müller, H. J., & Krüger, A. (2007). How much to bid in Digital Signage Advertising Auctions? *International Conference on Pervasive Computing (Pervasive 2007) Adjunct Workshop*, 2–5.

Musyoka, K. J., & Lim, G. G. (2017). Designing an Intelligent Advertising

Business Model in Seoul's Metro Network. *Journal of Intelligence and Information Systems*, Vol. 23(January 2018), 1–31. <https://doi.org/10.13088/jiis.2017.23.4.001>

Nweke, H. F., Teh, Y. W., Al-garadi, M. A., & Alo, U. R. (2018). Deep learning algorithms for human activity recognition using mobile and wearable sensor networks: State of the art and research challenges. *Expert Systems with Applications*, 105, 233–261. <https://doi.org/10.1016/j.eswa.2018.03.056>

Odena, A., Olah, C., & Shlens, J. (2017). Conditional image synthesis with auxiliary classifier gans. *34th International Conference on Machine Learning, ICML 2017*, 6, 4043–4055.

Osman, O. F. E., & Yap, M. H. (2019). Computational Intelligence in Automatic Face Age Estimation: A Survey. *IEEE Transactions on Emerging Topics in Computational Intelligence*, 3(3), 271–285. <https://doi.org/10.1109/TETCI.2018.2864554>

Papernot, N., Mcdaniel, P., Jha, S., Fredrikson, M., Celik, Z. B., & Swami, A. (2016). The limitations of deep learning in adversarial settings. *Proceedings - 2016 IEEE European Symposium on Security and Privacy, EURO S and P 2016*, 372–387. <https://doi.org/10.1109/EuroSP.2016.36>

Patel, J., Pandya, S., & Shah, V. (2017). Review on Generative Adversarial Networks. *International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)*, 4(7), 1230–1235.

Patel, T. B., & Patel, J. T. (2018). Occlusion detection and recognizing human face using neural network. *Proceedings of 2017 International Conference on Intelligent Computing and Control, I2C2 2017, 2018-Janua*, 1–4. <https://doi.org/10.1109/I2C2.2017.8321959>

- Pulli, K., Baksheev, A., Korniyakov, K., & Eruhimov, V. (2012). Real-Time Computer Vision With OpenCV. *Communications of the ACM*, 55(6), 61–69. <https://doi.org/10.1145/2184319.2184337>
- Qian, N. (1999). On the momentum term in gradient descent learning algorithms. *Neural Networks*, 12(1), 145–151. [https://doi.org/10.1016/S0893-6080\(98\)00116-6](https://doi.org/10.1016/S0893-6080(98)00116-6)
- Radford, A., Metz, L., & Chintala, S. (2016). Unsupervised representation learning with deep convolutional generative adversarial networks. *4th International Conference on Learning Representations, ICLR 2016 - Conference Track Proceedings*, 1–16.
- Ravi, D., Wong, C., Deligianni, F., Berthelot, M., Andreu-Perez, J., Lo, B., & Yang, G. Z. (2017). Deep Learning for Health Informatics. *IEEE Journal of Biomedical and Health Informatics*, 21(1), 4–21. <https://doi.org/10.1109/JBHI.2016.2636665>
- Rawat, W., & Wang, Z. (2017). Deep Convolutional Neural Networks for Image Classification: A Comprehensive Review. *Neural Computation*, 29(9), 2352–2449. https://doi.org/10.1162/neco_a_00990
- Rosasco, L., Vito, E. De, Caponnetto, A., Piana, M., & Verri, A. (2004). Are Loss Functions All the Same? *Neural Computation*, 16(5), 1063–1076. <https://doi.org/10.1162/089976604773135104>
- Rosebrock, A. (2017). *Deep Learning For Computer Vision with Python: Starter Bundle, 1st ed. Pyimagesearch*.
- Ruder, S. (2016). *An overview of gradient descent optimization algorithms*. 1–14. <http://arxiv.org/abs/1609.04747>

- Ryan, Ø. (2019). *Linear Algebra, Signal Processing and Wavelets - A Unified Approach : Python Version*. Springer.
- Salimans, T., Goodfellow, I., Zaremba, W., Cheung, V., Radford, A., & Chen, X. (2016). Improved techniques for training GANs. *Advances in Neural Information Processing Systems*, *19*(1), 2234–2242. <https://doi.org/10.1186/s12859-018-2152-z>
- Saqr, R., & Vivona, S. (2019). CapsGAN: Using Dynamic Routing for Generative Adversarial Networks. *Science and Information Conference*, *944*, 511–525. https://doi.org/10.1007/978-3-030-17798-0_41
- Schmidhuber, J. (2015). Deep Learning in neural networks: An overview. *Neural Networks*, *61*, 85–117. <https://doi.org/10.1016/j.neunet.2014.09.003>
- Schönböck, J., König, F., Kotsis, G., Gruber, D., Zaim, E., & Schmidt, A. (2008). MirrorBoard – An Interactive Billboard. *Proceedings of Mensch and Computer / Lübeck*, 217–226. <https://doi.org/10.1524/9783486598650.217>
- Shao, S., Wang, P., & Yan, R. (2019). Generative adversarial networks for data augmentation in machine fault diagnosis. *Computers in Industry*, *106*, 85–93. <https://doi.org/10.1016/j.compind.2019.01.001>
- Shi, W., Caballero, J., Theis, L., Huszar, F., Aitken, A., Ledig, C., & Wang, Z. (2016). *Is the deconvolution layer the same as a convolutional layer?* <http://arxiv.org/abs/1609.07009>
- Shorten, C., & Khoshgoftaar, T. M. (2019). A survey on Image Data Augmentation for Deep Learning. *Journal of Big Data*, *6*(1). <https://doi.org/10.1186/s40537-019-0197-0>
- Shrestha, A., & Mahmood, A. (2019). Review of deep learning algorithms and

architectures. *IEEE Access*, 7, 53040–53065.
<https://doi.org/10.1109/ACCESS.2019.2912200>

Siegel, A. F. (2016). Chapter 11 - Correlation and Regression: Measuring and Predicting Relationships. In A. F. Siegel (Ed.), *Practical Business Statistics (Seventh Edition)* (Seventh Ed, pp. 299–354). Academic Press.
<https://doi.org/10.1016/B978-0-12-804250-2.00011-0>

Singh, R. G., & Kishore, N. (2013). The impact of transformation function on the classification ability of complex valued extreme learning machines. *2013 International Conference on Control, Computing, Communication and Materials (ICCCCM)*, 1–5. <https://doi.org/10.1109/ICCCCM.2013.6648924>

Smith, G. (2015). 10 - Multiple Regression. In G. Smith (Ed.), *Essential Statistics, Regression, and Econometrics (Second Edition)* (Second Ed, pp. 301–337). Academic Press. <https://doi.org/10.1016/B978-0-12-803459-0.00010-8>

Somerville, I. (2011). *Software Engineering: Ninth Edition*. Addison-Wesley.

Srivastava, N., Hinton, G., Krizhevsky, A., Sutskever, I., & Salakhutdinov, R. (2014). Dropout: A Simple Way to Prevent Neural Networks from Overfitting. *J. Mach. Learn. Res.*, 15(1), 1929–1958. [https://doi.org/10.1016/0370-2693\(93\)90272-J](https://doi.org/10.1016/0370-2693(93)90272-J)

Sümer, E., Sümer, S. I., & Oğul, H. (2018). A novel computer vision-based advertisement system for individual marketing. *Tehnicki Vjesnik*, 25(5), 1485–1491. <https://doi.org/10.17559/TV-20161220142243>

Szegedy, C., Liu, W., Jia, Y., Sermanet, P., Reed, S., Anguelov, D., Erhan, D., Vanhoucke, V., & Rabinovich, A. (2015). Going Deeper With Convolutions. *Proceedings of the IEEE Conference on Computer Vision and Pattern*

Recognition, 1–9. <https://doi.org/10.1002/jctb.4820>

Szegedy, C., Vanhoucke, V., Ioffe, S., Shlens, J., & Wojna, Z. (2016). Rethinking the Inception Architecture for Computer Vision. *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2016-Decem*, 2818–2826. <https://doi.org/10.1109/CVPR.2016.308>

Tanaka, F. H. K. dos S., & Aranha, C. (2019). *Data Augmentation Using GANs. 2019*, 1–16. <http://arxiv.org/abs/1904.09135>

Taspinar, M., Naskali, A. T., Eren, G., & Kurt, M. (2012). The importance of customized advertisement delivery using 3D tracking and facial recognition. *2012 2nd International Conference on Digital Information and Communication Technology and Its Applications, DICTAP 2012, 11*, 520–524. <https://doi.org/10.1109/DICTAP.2012.6215365>

Taylor, D. G., Lewin, J. E., & Strutton, D. (2011). Friends, fans, and followers: Do ads work on social networks? How gender and age shape receptivity. *Journal of Advertising Research, 51*(1), 258–275. <https://doi.org/10.2501/JAR-51-1-258-275>

Thakur, S., & Verma, L. (2012). Age identification of Facial Images using Neural Network. *International Journal of Computer Science and Information Technologies, 3*(3), 4244–4247.

Turhan, C. G., & Bilge, H. S. (2018). Recent Trends in Deep Generative Models: A Review. *UBMK 2018 - 3rd International Conference on Computer Science and Engineering, July*, 574–579. <https://doi.org/10.1109/UBMK.2018.8566353>

Venkatesan, R., & Li, B. (2018). *Convolutional Neural Networks in Visual Computing : A Concise Guide*. CRC Press.

- Viola, P., & Jones, M. (2001). Rapid Object Detection using a Boosted Cascade of Simple Feature. *Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 1. <https://doi.org/10.1109/CVPR.2001.990517>
- Waibel, A., Hanazawa, T., Hinton, G., Shikano, K., & Lang, K. J. (1989). Phoneme recognition using time-delay neural networks. *IEEE Transactions on Acoustics, Speech, and Signal Processing*, 37(3), 328–339. <https://doi.org/10.1109/29.21701>
- Wan, J., Tan, Z., Lei, Z., Guo, G., & Li, S. Z. (2018). Auxiliary Demographic Information Assisted Age Estimation With Cascaded Structure. *IEEE Transactions on Cybernetics*, 48(9), 2531–2541. <https://doi.org/https://doi.org/10.1109/TCYB.2017.2741998>
- Wang, J., & Perez, L. (2017). *The Effectiveness of Data Augmentation in Image Classification using Deep Learning*. <http://arxiv.org/abs/1712.04621>
- Xing, J., Li, K., Hu, W., Yuan, C., & Ling, H. (2017). Diagnosing deep learning models for high accuracy age estimation from a single image. *Pattern Recognition*, 66(November 2016), 106–116. <https://doi.org/https://doi.org/10.1016/j.patcog.2017.01.005>
- Yang, M., Zhu, S., Lv, F., & Yu, K. (2011). Correspondence driven adaptation for human profile recognition. *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 1(c), 505–512. <https://doi.org/10.1109/CVPR.2011.5995481>
- Yann, L., & Yoshua, B. (1995). *Convolutional Networks for Images, Speech, and Time-Series*. 4(April 2016), 2571–2575. <https://doi.org/10.1109/IJCNN.2004.1381049>

- Yoshua, B. (2012). Practical Recommendations for Gradient-Based Training of Deep Architectures. *Neural Networks: Triicks of the Trade*, 437–478. https://doi.org/10.1007/978-3-642-35289-8_26
- Yu, D., Deng, L., Jang, I., Kudumakis, P., Sandler, M., & Kang, K. (2011). Deep learning and its applications to signal and information processing. *IEEE Signal Processing Magazine*, 28(1), 145–150. <https://doi.org/10.1109/MSP.2010.939038>
- Yu, T. J., Lee, C. P., Lim, K. M., & Razak, S. F. A. (2019). AI-based targeted advertising system. *Indonesian Journal of Electrical Engineering and Computer Science*, 13(2), 787–793. <https://doi.org/10.11591/ijeecs.v13.i2.pp787-793>
- Zeiler, M. D., Krishnan, D., Taylor, G. W., & Fergus, R. (2010). Deconvolutional networks. *2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 2528–2535. <https://doi.org/10.1109/CVPR.2010.5539957>
- Zeiler, M. D., Taylor, G. W., & Fergus, R. (2011). Adaptive deconvolutional networks for mid and high level feature learning. *2011 International Conference on Computer Vision*, 2018–2025. <https://doi.org/10.1109/ICCV.2011.6126474>
- Zhan, Y., Hu, D., Wang, Y., & Yu, X. (2018). Semisupervised Hyperspectral Image Classification Based on Generative Adversarial Networks. *IEEE Geoscience and Remote Sensing Letters*, 15(2), 212–216. <https://doi.org/10.1109/LGRS.2017.2780890>
- Zhang, Z., Song, Y., & Qi, H. (2017). Age Progression / Regression by Conditional Adversarial Autoencoder. *Proceedings of the IEEE Conference on Computer*

Vision and Pattern Recognition (CVPR), 5810–5818.

Zhao, J. J., Mathieu, M., & Lecun, Y. (2016). Energy-based Generative Adversarial Network. *CoRR*, *abs/1609.0*. <http://arxiv.org/abs/1609.03126>

Zhu, X., Liu, Y., Li, J., Wan, T., & Qin, Z. (2018). Emotion classification with data augmentation using generative adversarial networks. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *10939 LNAI*, 349–360. https://doi.org/10.1007/978-3-319-93040-4_28

Zhu, Z., Chen, H., Hu, Y., & Li, J. (2018). Age Estimation Algorithm Of Facial Images Based On Multi-Label Sorting. *Eurasip Journal on Image and Video Processing*, *2018*(1). <https://doi.org/10.1186/s13640-018-0353-z>