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| **K. K. WAGH INSTITUTE OF ENGINEERING EDUCATION & RESEARCH, NASHIK 422003**  **DEPARTMENT OF COMPUTER ENGINEERING**  **PROJECT WORK BOOK**    **Academic Year 2020 - 2021**   |  | | --- | | **Group No: 23** |   **Project Title: Astronomical Image colorization and super-resolution using**  **Generative Adversarial Networks**  **Area of Project: Deep Learning, Generative Models**  **Sponsored by: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**  **Course: B.E. Computer**   |  |  |  | | --- | --- | --- | | **Sr.No.** | **Roll No** | **Name of Student** | | **S1** | 17 | Shreyas Kalvankar | | **S2** | 18 | Hrushikesh Pandit | | **S3** | 19 | Pranav Parwate | | **S4** | 20 | Atharva Patil |     **Name of Project Guide: Prof. Dr. S. M. Kamalapur**  1  **ABSTRACT**  Automated colorization of gray scale images has been subjected to much research within the computer vision and machine learning communities. Beyond simply being fascinating from an aesthetic and artificial intelligence perspective, such capability has broad practical applications. It is an area of research that possesses great potentials in applications: from black and white photo reconstruction, image augmentation, video restoration to image enhancement for improved interpretability.  Image downscaling is an innately lossy process. The principal objective of super resolution imaging is to reconstruct a low-resolution image into a high resolution one based on a set of low-resolution images to rectify the limitations that existed while the procurement of the original low-resolution images. This is to insure better visualization and recognition for either scientific or non-scientific purposes. Even if an upscaling algorithm is particularly good, there will always be some amount of high frequency data lost from a downscale-upscale function performed on the image. Ultimately, even the best upscaling algorithms are unable to effectively reconstruct data that does not exist. Traditional methods for image up sampling rely on low-information, smooth interpolation between known pixels. Such methods can be treated as a convolution with a kernel encoding no information about the original image. A solution to the problem is by using Generative Adversarial Networks (GANs) to hallucinate high frequency data in a super scaled image that does not exist in the smaller image. Even though they increase the resolution of an image, they fail to produce the clarity desired in the super-resolution task. By using the above-mentioned method, not a perfect reconstruction can be obtained albeit instead a rather plausible guess can be made at what the lost data might be, constrained to reality by a loss function penalizing deviations from the ground truth image.  A huge number of raw images are present unprocessed and unnoticed in the Hubble Legacy Archives. These raw images are typically black and white, low-resolution and unfit to be shared with the world. It takes huge amounts of hours to process them. This processing is necessary because it’s difficult for astronomers to distinguish objects from the raw images. Random and synthetic noise from the sensors in the telescope, changing optical characteristics in the system and noise from other bodies in the universe all make the processing further necessary. Furthermore, for the process of highlighting small features that ordinarily wouldn’t be able to be picked out against noise of the image, we need colorization. The processing of the images is so time consuming that the images are rarely seen by human eyes. The problem is only likely to get worse. Not only is new data being continuously produced by Hubble Telescope, but new telescopes are soon to come online. A simplification of image processing by using artificial image colorization and super-resolution can be done in an automated fashion to make it easier for astronomers to visually identify and analyze objects in Hubble dataset.  **Signature of the students Name & Signature of Guide**  1  **Block Diagram**    Figure 1: Basic Block diagram    Figure 2: GAN block  **Signature of the students Name & Signature of Guide**  **2**  **EXPECTED OUTCOMES OF PROJECT:**  The expected outcomes of the proposed methodology are as follows:   * An efficient mathematical model to be created which will describe mappings required to colorize and super-resolve low resolution grayscale images * A brief albeit descriptive study of different approaches towards image colorization and super-resolution * Study presenting the benefits of certain GAN architectures and their edge over other kinds of neural networks in image colorization and super-resolution   **Signature of the students Name & Signature of Guide**  3  **List Of Related Publication (Literature):**  (Students should mention minimum 10 reputed journal papers supporting the project ideas.)  Arjovsky, M., Chintala, S. and Bottou, L. (2017). Wasserstein gan.  Cheng, Z., Yang, Q. and Sheng, B. (2016). Deep colorization.  Dahl, R. (2016). Automatic colorization.  Dong, C., Loy, C. C., He, K. and Tang, X. (2014). Learning a deep convolutional network for image super-resolution, in D. Fleet, T. Pajdla, B. Schiele and T. Tuytelaars (eds), Computer Vision – ECCV 2014, Springer International Publishing, Cham, pp. 184–199.  Goodfellow, I. J., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A. and Bengio, Y. (2014). Generative adversarial networks.  He, K., Zhang, X., Ren, S. and Sun, J. (2015). Deep residual learning for image  recognition.  Huang, Y.-C., Tung, Y.-S., Chen, J.-C., Wang, S.-W. and Wu, J.-L. (2005). An  adaptive edge detection based colorization algorithm and its applications, pp. 351–354.  Isola, P., Zhu, J.-Y., Zhou, T. and Efros, A. A. (2018). Image-to-image translation with conditional adversarial networks.  Jianchao Yang, Wright, J., Huang, T. and Yi Ma (2008). Image super-resolution as sparse representation of raw image patches, 2008 IEEE Conference on Computer Vision and Pattern Recognition, pp. 1–8.  Karras, T., Aila, T., Laine, S. and Lehtinen, J. (2018). Progressive growing of gans for improved quality, stability, and variation.  Kim, J., Lee, J. K. and Lee, K. M. (2016). Accurate image super-resolution using very deep convolutional networks, 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1646–1654.  Ledig, C., Theis, L., Huszar, F., Caballero, J., Cunningham, A., Acosta, A., Aitken, A., Tejani, A., Totz, J., Wang, Z. and Shi, W. (2017). Photo-realistic single image super-resolution using a generative adversarial network.  Levin, A., Lischinski, D. andWeiss, Y. (n.d.). Colorization using optimization, ACM SIGGRAPH 2004 Papers, ACM Journals.  Lim, B., Son, S., Kim, H., Nah, S. and Lee, K. M. (2017). Enhanced deep residual networks for single image super-resolution.  Long, J., Shelhamer, E. and Darrell, T. (2015). Fully convolutional networks for  semantic segmentation, 2015 IEEE Conference on Computer Vision and Pattern  Recognition (CVPR), pp. 3431–3440.  Mirza, M. and Osindero, S. (2014). Conditional generative adversarial nets.  Pressman, R. S. (1992). Software Engineering (3rd Ed.): A Practitioner’s Approach, McGraw-Hill, Inc., New York, NY, USA.  Qu, Y.,Wong, T.-T. and Heng, P.-A. (2006). Manga colorization, ACM Transactions on Graphics (TOG) 25(3): 1214–1220.  Radford, A., Metz, L. and Chintala, S. (2016). Unsupervised representation learning with deep convolutional generative adversarial networks.  Shi, W., Caballero, J., Husz´ar, F., Totz, J., Aitken, A. P., Bishop, R., Rueckert, D. and Wang, Z. (2016). Real-time single image and video super-resolution using an efficient sub-pixel convolutional neural network, 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1874–1883.  Simonyan, K. and Zisserman, A. (2015). Very deep convolutional networks for  large-scale image recognition.  Tola, E., Lepetit, V. and Fua, P. (2008). A fast local descriptor for dense matching, Proc. CVPR . Tom and Katsaggelos (1996)., in Anon (ed.), IEEEInternational Conference on Image Processing, Vol. 2, IEEE, pp. 539–542. Proceedings of the 1995 IEEE International Conference on Image Processing. Part 3 (of 3) ; Conference date: 23-10-1995 Through 26-10-1995.  TSAI, R. (1984). Multiframe image restoration and registration, Advance Computer Visual and Image Processing 1: 317–339.  URL: <https://ci.nii.ac.jp/naid/10026807118/en/>  Welsh, T., Ashikhmin, M. and Mueller, K. (2002). Transferring color to greyscale  images, ACM Trans. Graph. 21: 277–280.  Yatziv, L. and Sapiro, G. (2006). Fast image and video colorization using chrominance blending, IEEE Transactions on Image Processing 15(5): 1120–1129.  Yu, J., Fan, Y., Yang, J., Xu, N., Wang, Z., Wang, X. and Huang, T. (2018). Wide activation for efficient and accurate image super-resolution.  Zhu, J.-Y., Kr¨ahenb¨uhl, P., Shechtman, E. and Efros, A. A. (2018). Generative visual manipulation on the natural image manifold.  **Signature of the students Name & Signature of Guide**  4  **Monthly Planning Sheet**  (To be prepared by the student)  BE (Semester VII)  **Month: August**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2,3** | **Project topic selection and finalization** | **Topic finalized** |  |  | | **4** | **Idea presentation** | **Prepared and presented project idea** |  |  | |  |  |  |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: September**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2** | **Finding potential dataset** | **Decided on the data to be used from Hubble Legacy Archive** |  |  | | **3** | **Find techniques to create data set** | **Found scraping tools** |  |  | | **4(a month)** | **Collect data** | **Started scraping the archive** |  |  | |  |  |  |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: October**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2** | **Study different Image colorization techniques** | **Gathering of reference papers, articles and reports for image colorization** |  |  | | **3,4** | **Survey of colorization techniques** | **Literature review of image colorization along with data scraper** |  |  | |  |  |  |  |  |   **Month: November**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2** | **Study super resolution techniques** | **Gathering of reference material** |  |  | | **3,4** | **Literature survey** | **Started literature survey** |  |  | |  |  |  |  |  | |  |  |  |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: December**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2** | **Literature review** | **Complete review of literature** |  |  | | **3** | **Implementation of basic GAN model** | **Started working towards basic code** |  |  | | **4** | **Report and presentation** | **Started working towards stage 1 report submission and presentation** |  |  | |  |  |  |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: January**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **2** | **Report and presentation completion** | **Presentation completed** |  |  | | **3** | **Report completion** | **Completed stage 1 report** |  |  | | **4** | **Work on different GAN architectures for colorization** | **Implemented VGG architecture** |  |  | | **4** | **Basic SR GAN coding** | **Started working towards implementation approach** |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: February**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2** | **Setting up basic input pipeline** | **Cleaned dataset and set up basic input pipeline** |  |  | | **3** | **Create ResNet model in RGB colorspace** | **Implemented and started training U-net models in tensorflow** |  |  | | **4** | **Explore usage of L\*a\*b color spaces** | **Set up basic model in torch** |  |  | | **4** | **Set up training pipeline for SR GAN** | **Started training Ledig’s SRGAN** |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: March**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2** | **Use different U-net models for increasing performance** | **Experimented with various discriminator and generator models** |  |  | | **3** | **Set up testing pipeline** | **Set up a testing pipeline for keras image colorization model** |  |  | | **4** | **Compare RGB and L\*a\*b performance** | **Results compared visually** |  |  | | **4** | **U-net backbone training on larger COCO dataset** | **Set up data, training and testing pipeline and model architecture** |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: April**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1** | **Train model on COCO** | **Observed training performance on COCO** |  |  | | **2** | **Decide on performance metrics** | **Decided on qualitative and quantitative metrics** |  |  | | **3** | **Train to finetune torch model in L\*a\*b space** | **Tested outputs and begun training** |  |  | | **4** | **Improve on Lr, decay rate for optimized results** | **Observed training curves and finetuned model parameters** |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Month: May**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Week No.(with duration)** | **Activity Planned** | **Activity Completed** | **Signature of the students** | **Signature of Internal/External Guide** | | **1,2** | **Testing models and defining a comparative study** | **Tested all model architectures in qualitative and quantitative fashion** |  |  | | **3** | **Document findings** | **Started working on stage 2 report and presentation** |  |  | | **4** | **Complete stage 2 report and presentation** | **Completed project documentation and presentation** |  |  | |  |  |  |  |  | |  |  |  |  |  | |  |  |  |  |  |   **Project Coordinator**  13 |