Topic: Classification of localized defects on silicon carbide (SiC) wafers using domain adaptation techniques

Defect detection and classification is an essential part of the manufacturing process in industry. The identification of errors is the basis for the improvement of production pipelines and therefore increases the overall output of defect-free products.

The Intego GmbH - a medium-sized company located in Erlangen - develops and produces customer-specific inspection systems. They apply the latest measurement and imaging technologies to perform complex inspection tasks reliably [1]. Intego developed an optical inspection system for the Fraunhofer IISB to detect and classify defects on silicon carbide (SiC) wafers with aid of various sensors and traditional state of the art image processing techniques [2].

Their system uses ResNet [3] for the classification of defects on SiC-wafers, outperforming classical algorithms by a large margin. However, on images with a different manufacturing or inspection process, the performance of ResNet [3] trained on the original dataset degrades considerably. This is due to a change in the distribution of features and labels, i.e. defect classes, image contrast, etc.

In literature, this problem is called Domain Shift [4, 5, 6, 7]. The most used method to solve this issue is fine-tuning of the network parameters on the new data. Lee et al. [5] applied this technique on a similar industrial dataset DAGM [8]. They outperformed their baseline model with frozen layers by 14.95%. Though, one disadvantage of fine-tuning is the requirement of labels on the new domain. Tzeng et al. [6] proposed an unsupervised domain adaptation system using adversarial training on the problem of character classification and cross-modality adaptation. Kouw et al. [7] proposes the use of several, known techniques like importance weighting or sub space mapping, depending on the kind of data shift. For example, for Covariate Shift, importance sampling should be used.

This thesis applies domain adaptation techniques frequently used in literature to the application area of SiC-wafer defect classification. The goal is to achieve a performance similar to the original dataset, on the new dataset with little to no labeling.

Within the thesis the following steps have to be conducted:

1. Literature research on domain adaptation techniques
2. Labeling of artifact classes on SiC-wafer images with a shifted data distribution, compared to the dataset used in Ref. [2]
3. Estimation of the domain shift between the original and the shifted dataset using baseline models (e.g. ResNet [3])
4. Implementation and evaluation of domain adaptation techniques (e.g. Lee et al. [5], Tzeng et al. [6])

The thesis must contain a detailed description of all developed and used algorithms as well as a profound result evaluation and discussion. The implemented code has to be documented and provided. An extended research on literature, existing patents and related work in the corresponding areas has to be performed. No prior knowledge about the physics of SiC is required. The student needs to be aware of the fact that (s)he needs to sign a non-disclosure agreement for the use of sensible data provided by Intego GmbH.

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Start – End: Any time / as soon as possible

References

[1] Intego GmbH - `https://www.intego.de/en/`

[2] Doll, A (2018), Deep Learning Algorithmen im Leistungsvergleich zu konventionellen Klassifikationsverfahren an Beispielen der industriellen Sichtprüfung, Master's Thesis

[3] He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep residual learning for image recognition. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2016-December, 770–778. https://doi.org/10.1109/CVPR.2016.90

[4] Y. Luo, L. Zheng, T. Guan, J. Yu and Y. Yang, "Taking a Closer Look at Domain Shift: Category-Level Adversaries for Semantics Consistent Domain Adaptation,"2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), Long Beach, CA, USA, 2019, pp. 2502-2511, doi: 10.1109/CVPR.2019.00261.

[5] Kim, S., Kim, W., Noh, Y. K., & Park, F. C. (2017). Transfer learning for automated optical inspection. Proceedings of the International Joint Conference on Neural Networks, 2017-May, 2517–2524. https://doi.org/10.1109/IJCNN.2017.7966162

[6] Tzeng, E., Hoffman, J., Saenko, K., & Darrell, T. (2017). Adversarial discriminative domain adaptation. Proceedings - 30th IEEE Conference on Computer Vision and Pattern Recognition, CVPR 2017, 2017-Janua, 2962–2971. https://doi.org/10.1109/CVPR.2017.316

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[8] DAGM Dataset of the DAGM 2007 Challenge, Retrieved from https://resources.mpi-inf.mpg.de/conference/dagm/2007/prizes.html