



Automated quality assurance of deep learning contours in head-and-neck radiotherapy

Mody, P.P.

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References

- [1] Charlotte L Brouwer et al. “CT-based delineation of organs at risk in the head and neck region: DAHANCA, EORTC, GORTEC, HKNPCSG, NCIC CTG, NCRI, NRG Oncology and TROG consensus guidelines”. In: *Radiotherapy and Oncology* 117.1 (2015), pp. 83–90.
- [2] United States government. *Head and Neck Cancers*. 2021. URL: <https://www.cancer.gov/types/head-and-neck/head-neck-fact-sheet>.
- [3] Foteini Simopoulou et al. “Does adaptive radiotherapy for head and neck cancer favorably impact dosimetric, clinical, and toxicity outcomes?: A review”. In: *Medicine* 103.26 (2024), e38529.
- [4] Jakub Grepl et al. “MRI-based adaptive radiotherapy has the potential to reduce dysphagia in patients with head and neck cancer”. In: *Physica Medica* 105 (2023), p. 102511.
- [5] Stephanie Lim-Reinders et al. “Online Adaptive Radiation Therapy”. In: *Int J Radiat Oncol Biol Phys* 99 (2017), pp. 994–1003. URL: <https://doi.org/10.1016/j.ijrobp.2017.04.023>.
- [6] Charlotte L Brouwer et al. “3D variation in delineation of head and neck organs at risk”. In: *Radiation Oncology* 7.1 (2012), pp. 1–10.
- [7] Shivakumar Gudi et al. “Interobserver variability in the delineation of gross tumour volume and specified organs-at-risk during IMRT for head and neck cancers and the impact of FDG-PET/CT on such variability at the primary site”. In: *Journal of medical imaging and radiation sciences* 48.2 (2017), pp. 184–192.
- [8] Julie van der Veen, Akos Gulyban, and Sandra Nuyts. “Interobserver variability in delineation of target volumes in head and neck cancer”. In: *Radiotherapy and Oncology* 137 (2019), pp. 9–15.
- [9] Julie van der Veen, Akos Gulyban, and Sandra Nuyts. “Interobserver variability in delineation of target volumes in head and neck cancer”. In: *Radiotherapy and Oncology* 137 (2019), pp. 9–15.
- [10] Jordan Wong et al. “Comparing deep learning-based auto-segmentation of organs at risk and clinical target volumes to expert inter-observer variability in radiotherapy planning”. In: *Radiother Oncol* 144 (2020), pp. 152–158. URL: <https://doi.org/10.1016/j.radonc.2019.10.019>.
- [11] J. van der Veen et al. “Interobserver variability in organ at risk delineation in head and neck cancer”. In: *Radiat Oncol* 16 (2021), pp. 1–11. URL: <https://doi.org/10.1186/s13014-020-01677-2>.
- [12] Ruta Zukauskaite et al. “Delineation uncertainties of tumour volumes on MRI of head and neck cancer patients”. In: *Clinical and Translational Radiation Oncology* 36 (2022), pp. 121–126.

[13] Michaël Claessens et al. “Quality assurance for AI-based applications in radiation therapy”. In: *Seminars in radiation oncology*. Vol. 32. 4. Elsevier. 2022, pp. 421–431.

[14] Sandra Nuyts et al. “Adaptive radiotherapy for head and neck cancer: Pitfalls and possibilities from the radiation oncologist’s point of view”. In: *Cancer Medicine* 13.8 (2024), e7192.

[15] Dan Nguyen et al. “3D radiotherapy dose prediction on head and neck cancer patients with a hierarchically densely connected U-net deep learning architecture”. In: *Physics in medicine & Biology* 64.6 (2019), p. 065020.

[16] Masahide Saito et al. “Evaluation of deep learning based dose prediction in head and neck cancer patients using two different types of input contours”. In: *Journal of Applied Clinical Medical Physics* 25.12 (2024), e14519.

[17] Yanxia Liu et al. “CT synthesis from MRI using multi-cycle GAN for head-and-neck radiation therapy”. In: *Computerized medical imaging and graphics* 91 (2021), p. 101953.

[18] Wen Chen et al. “Clinical enhancement in AI-based post-processed fast-scan low-dose CBCT for head and neck adaptive radiotherapy”. In: *Frontiers in artificial intelligence* 3 (2021), p. 614384.

[19] Adrian Thummerer et al. “SynthRAD2023 Grand Challenge dataset: Generating synthetic CT for radiotherapy”. In: *Medical physics* 50.7 (2023), pp. 4664–4674.

[20] Patrik F Raudaschl et al. “Evaluation of segmentation methods on head and neck CT: Auto-segmentation challenge 2015”. In: *Medical physics* 44.5 (2017), pp. 2020–2036.

[21] Margarita L Zuley et al. “Radiology data from the cancer genome atlas head-neck squamous cell carcinoma [TCGA-HNSC] collection”. In: *Cancer Imaging Arch* 10 (2016), K9.

[22] Stanislav Nikolov et al. “Clinically Applicable Segmentation of Head and Neck Anatomy for Radiotherapy: Deep Learning Algorithm Development and Validation Study”. In: *J Med Internet Res* 23.7 (July 2021), e26151. ISSN: 1438-8871. DOI: [10.2196/26151](https://doi.org/10.2196/26151). URL: <http://www.ncbi.nlm.nih.gov/pubmed/34255661>.

[23] Wentao Zhu et al. “AnatomyNet: Deep Learning for Fast and Fully Automated Whole-volume Segmentation of Head and Neck Anatomy”. In: *Medical physics* 46.2 (2019), pp. 576–589.

[24] Yunhe Gao et al. “FocusNet: Imbalanced large and small organ segmentation with an end-to-end deep neural network for head and neck CT images”. In: *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer. 2019, pp. 829–838.

[25] Ozan Oktay et al. “Evaluation of deep learning to augment image-guided radiotherapy for head and neck and prostate cancers”. In: *JAMA network open* 3.11 (2020), e2027426.

[26] Dazhou Guo et al. “Organ at risk segmentation for head and neck cancer using stratified learning and neural architecture search”. In: *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2020, pp. 4223–4232.

[27] Christina Hague et al. “An evaluation of MR based deep learning auto-contouring for planning head and neck radiotherapy”. In: *Radiotherapy and Oncology* 158 (2021), pp. 112–117.

[28] Yunhe Gao et al. "FocusNetv2: Imbalanced large and small organ segmentation with adversarial shape constraint for head and neck CT images". In: *Medical Image Analysis* 67 (2021), p. 101831.

[29] Zijie Chen et al. "A Novel Hybrid Convolutional Neural Network for Accurate Organ Segmentation in 3D Head and Neck CT Images". In: *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer. 2021, pp. 569–578.

[30] John C Asbach et al. "Deep learning tools for the cancer clinic: an open-source framework with head and neck contour validation". In: *Radiation Oncology* 17.1 (2022), p. 28.

[31] Lucía Cubero et al. "Deep learning-based segmentation of head and neck organs-at-risk with clinical partially labeled data". In: *Entropy* 24.11 (2022), p. 1661.

[32] Peiru Liu et al. "Deep learning algorithm performance in contouring head and neck organs at risk: a systematic review and single-arm meta-analysis". In: *BioMedical Engineering On-Line* 22.1 (2023), p. 104.

[33] Skylar S Gay et al. "Fully-automated, CT-only GTV contouring for palliative head and neck radiotherapy". In: *Scientific reports* 13.1 (2023), p. 21797.

[34] Lisanne V van Dijk et al. "Improving automatic delineation for head and neck organs at risk by Deep Learning Contouring". In: *Radiotherapy and Oncology* 142 (2020), pp. 115–123.

[35] Charlotte L Brouwer et al. "Assessment of manual adjustment performed in clinical practice following deep learning contouring for head and neck organs at risk in radiotherapy". In: *Physics and imaging in radiation oncology* 16 (2020), pp. 54–60.

[36] Jordan Wong et al. "Implementation of deep learning-based auto-segmentation for radiotherapy planning structures: a workflow study at two cancer centers". In: *Radiation Oncology* 16.1 (2021), p. 101.

[37] Yang Zhong et al. "A preliminary experience of implementing deep-learning based auto-segmentation in head and neck cancer: a study on real-world clinical cases". In: *Frontiers in oncology* 11 (2021), p. 638197.

[38] Andrea D'Aviero et al. "Clinical validation of a deep-learning segmentation software in head and neck: an early analysis in a developing radiation oncology center". In: *International Journal of Environmental Research and Public Health* 19.15 (2022), p. 9057.

[39] Yasmin McQuinlan et al. "An investigation into the risk of population bias in deep learning autocontouring". In: *Radiotherapy and Oncology* 186 (2023), p. 109747.

[40] Yunfei Hu et al. "Clinical assessment of a novel machine-learning automated contouring tool for radiotherapy planning". In: *Journal of Applied Clinical Medical Physics* 24.7 (2023), e13949.

[41] J. John Lucido et al. "Validation of clinical acceptability of deep-learning-based automated segmentation of organs-at-risk for head-and-neck radiotherapy treatment planning". In: *Front Oncol* 13 (2023). URL: <https://doi.org/10.3389/fonc.2023.1137803>.

[42] Patrik F Raudaschl et al. "Evaluation of segmentation methods on head and neck CT: Auto-segmentation challenge 2015". In: *Medical physics* 44.5 (2017), pp. 2020–2036.

[43] Stanislav Nikolov et al. “Clinically applicable segmentation of head and neck anatomy for radiotherapy: deep learning algorithm development and validation study”. In: *Journal of Medical Internet Research* 23.7 (2021), e26151.

[44] Valentin Oreiller et al. “Head and neck tumor segmentation in PET/CT: the HECKTOR challenge”. In: *Medical image analysis* 77 (2022), p. 102336.

[45] J. P. Kieselmann et al. “Geometric and dosimetric evaluations of atlas-based segmentation methods of MR images in the head and neck region”. In: *Phys Med Biol* 63 (2018), aacb65. URL: <https://doi.org/10.1088/1361-6560/aacb65>.

[46] Ward van Rooij et al. “Deep Learning-Based Delineation of Head and Neck Organs at Risk: Geometric and Dosimetric Evaluation”. In: *Int J Radiat Oncol Biol Phys* 104 (2019), pp. 677–684. URL: <https://doi.org/10.1016/j.ijrobp.2019.02.040>.

[47] Lisanne V. van Dijk et al. “Improving automatic delineation for head and neck organs at risk by Deep Learning Contouring”. In: *Radiother Oncol* 142 (2020), pp. 115–123. URL: <https://doi.org/10.1016/j.radonc.2019.09.022>.

[48] Hongbo Guo et al. “The dosimetric impact of deep learning-based auto-segmentation of organs at risk on nasopharyngeal and rectal cancer”. In: *Radiat Oncol* 16 (2021), pp. 1–14. URL: <https://doi.org/10.1186/s13014-021-01837-y>.

[49] Andreas Johan Smolders et al. “Dosimetric comparison of autocontouring techniques for online adaptive proton therapy”. In: *Phys Med Biol* 68 (2023), p. 175006. URL: <https://doi.org/10.1088/1361-6560/ace307>.

[50] Jihye Koo et al. “Essentially unedited deep-learning-based OARs are suitable for rigorous oropharyngeal and laryngeal cancer treatment planning”. In: *J Appl Clin Med Phys* (2023), pp. 1–10. URL: <https://doi.org/10.1002/acm2.14202>.

[51] Camila González et al. “Distance-based detection of out-of-distribution silent failures for covid-19 lung lesion segmentation”. In: *Medical image analysis* 82 (2022), p. 102596.

[52] Davood Karimi and Ali Gholipour. “Improving calibration and out-of-distribution detection in deep models for medical image segmentation”. In: *IEEE Transactions on Artificial Intelligence* 4.2 (2022), pp. 383–397.

[53] Lyndon Boone et al. “ROOD-MRI: Benchmarking the robustness of deep learning segmentation models to out-of-distribution and corrupted data in MRI”. In: *NeuroImage* 278 (2023), p. 120289.

[54] Anton Vasiliuk et al. “Limitations of out-of-distribution detection in 3d medical image segmentation”. In: *Journal of Imaging* 9.9 (2023), p. 191.

[55] Zesheng Hong et al. “Out-of-distribution detection in medical image analysis: A survey”. In: *arXiv preprint arXiv:2404.18279* (2024).

[56] Felix JS Bragman et al. “Uncertainty in multitask learning: joint representations for probabilistic MR-only radiotherapy planning”. In: *Medical Image Computing and Computer Assisted Intervention–MICCAI 2018: 21st International Conference, Granada, Spain, September 16–20, 2018, Proceedings, Part IV* 11. Springer. 2018, pp. 3–11.

[57] Guotai Wang et al. “Aleatoric uncertainty estimation with test-time augmentation for medical image segmentation with convolutional neural networks”. In: *Neurocomputing* 338 (2019), pp. 34–45.

[58] Jörg Sander, Bob D de Vos, and Ivana Išgum. “Automatic segmentation with detection of local segmentation failures in cardiac MRI”. In: *Scientific Reports* 10.1 (2020), p. 21769.

[59] Alain Jungo, Fabian Balsiger, and Mauricio Reyes. “Analyzing the quality and challenges of uncertainty estimations for brain tumor segmentation”. In: *Frontiers in neuroscience* 14 (2020), p. 282.

[60] Guotai Wang et al. “Aleatoric uncertainty estimation with test-time augmentation for medical image segmentation with convolutional neural networks”. In: *Neurocomputing* 338 (2019), pp. 34–45.

[61] Tanya Nair et al. “Exploring uncertainty measures in deep networks for multiple sclerosis lesion detection and segmentation”. In: *Medical image analysis* 59 (2020), p. 101557.

[62] Alireza Mehrtash et al. “Confidence calibration and predictive uncertainty estimation for deep medical image segmentation”. In: *IEEE transactions on medical imaging* 39.12 (2020), pp. 3868–3878.

[63] Guotai Wang et al. “Uncertainty-guided efficient interactive refinement of fetal brain segmentation from stacks of MRI slices”. In: *Medical Image Computing and Computer Assisted Intervention–MICCAI 2020: 23rd International Conference, Lima, Peru, October 4–8, 2020, Proceedings, Part IV* 23. Springer. 2020, pp. 279–288.

[64] Azat Garifullin, Lasse Lensu, and Hannu Uusitalo. “Deep Bayesian baseline for segmenting diabetic retinopathy lesions: Advances and challenges”. In: *Computers in Biology and Medicine* 136 (2021), p. 104725.

[65] Cheng Ouyang et al. “Improved post-hoc probability calibration for out-of-domain MRI segmentation”. In: *Uncertainty for Safe Utilization of Machine Learning in Medical Imaging: 4th International Workshop, UNSURE 2022, Held in Conjunction with MICCAI 2022*. Springer. 2022, pp. 59–69.

[66] Matthew Ng et al. “Estimating Uncertainty in Neural Networks for Cardiac MRI Segmentation: A Benchmark Study”. In: *IEEE Transactions on Biomedical Engineering* (2022), pp. 1–12. DOI: [10.1109/TBME.2022.3232730](https://doi.org/10.1109/TBME.2022.3232730).

[67] Miguel Monteiro et al. “Stochastic segmentation networks: Modelling spatially correlated aleatoric uncertainty”. In: *Advances in Neural Information Processing Systems* 33 (2020), pp. 12756–12767.

[68] Sora Iwamoto et al. “Improving the Reliability of Semantic Segmentation of Medical Images by Uncertainty Modeling with Bayesian Deep Networks and Curriculum Learning”. In: *Uncertainty for Safe Utilization of Machine Learning in Medical Imaging, and Perinatal Imaging, Placental and Preterm Image Analysis*. Springer, 2021.

[69] Robin Camarasa et al. “A Quantitative Comparison of Epistemic Uncertainty Maps Applied to Multi-Class Segmentation”. In: *Machine Learning for Biomedical Imaging* 1. UNSURE2020 special issue (2021), pp. 1–10.

[70] Tewodros Weldebirhan Arega, Stéphanie Bricq, and Fabrice Meriaudeau. “Leveraging Uncertainty Estimates to Improve Segmentation Performance in Cardiac MR”. In: *Uncertainty for Safe Utilization of Machine Learning in Medical Imaging, and Perinatal Imaging, Placental and Preterm Image Analysis*. Springer, 2021, pp. 24–33.

[71] Mobarakol Islam and Ben Glocker. “Spatially varying label smoothing: Capturing uncertainty from expert annotations”. In: *Information Processing in Medical Imaging: 27th International Conference, IPMI 2021, Virtual Event, June 28–June 30, 2021, Proceedings 27*. Springer, 2021, pp. 677–688.

[72] Ishaan Bhat et al. “Influence of uncertainty estimation techniques on false-positive reduction in liver lesion detection”. In: *Machine Learning for Biomedical Imaging 1* (December 2022 issue 2022), pp. 1–33. ISSN: 2766-905X. DOI: [10.59275/j.melba.2022-5937](https://doi.org/10.59275/j.melba.2022-5937). URL: <https://melba-journal.org/2022:030>.

[73] Achim Hekler, Titus J Brinker, and Florian Buettner. “Test time augmentation meets post-hoc calibration: uncertainty quantification under real-world conditions”. In: *Proceedings of the AAAI Conference on Artificial Intelligence*. Vol. 37. 12. 2023, pp. 14856–14864.

[74] Hongwei Bran Li et al. “QUBIQ: Uncertainty Quantification for Biomedical Image Segmentation Challenge”. In: *arXiv preprint arXiv:2405.18435* (2024).

[75] Kareem A Wahid et al. “Artificial intelligence uncertainty quantification in radiotherapy applications- A scoping review”. In: *Radiotherapy and Oncology* (2024), p. 110542.

[76] Jörg Sander et al. “Towards increased trustworthiness of deep learning segmentation methods on cardiac MRIG”. In: *Medical Imaging 2019: Image Processing*. Vol. 10949. International Society for Optics and Photonics. 2019, p. 1094919.

[77] Alireza Mehrtash et al. “Confidence calibration and predictive uncertainty estimation for deep medical image segmentation”. In: *IEEE transactions on medical imaging* 39.12 (2020), pp. 3868–3878.

[78] Thomas Buddenotte et al. “Calibrating ensembles for scalable uncertainty quantification in deep learning-based medical image segmentation”. In: *Computers in Biology and Medicine* 163 (2023), p. 107096.

[79] Yidong Zhao et al. “Bayesian uncertainty estimation by hamiltonian monte carlo: Applications to cardiac mri segmentation”. In: *arXiv preprint arXiv:2403.02311* (2024).

[80] Dong Joo Rhee et al. “Automatic detection of contouring errors using convolutional neural networks”. In: *Medical physics* 46.11 (2019), pp. 5086–5097.

[81] Edward GA Henderson et al. “Automatic identification of segmentation errors for radiotherapy using geometric learning”. In: *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer. 2022, pp. 319–329.

[82] Lars Johannes Isaksson et al. “Quality assurance for automatically generated contours with additional deep learning”. In: *Insights into Imaging* 13.1 (2022), p. 137.

[83] Biling Wang et al. “AI-Assisted Decision-Making for Clinical Assessment of Auto-Segmented Contour Quality”. In: *arXiv preprint arXiv:2505.00308* (2025).

[84] Tomas Sakinis et al. “Interactive segmentation of medical images through fully convolutional neural networks”. In: *arXiv preprint arXiv:1903.08205* (2019).

[85] Zixiang Wei et al. “Towards interactive deep-learning for tumour segmentation in head and neck cancer radiotherapy”. In: *Physics and Imaging in Radiation Oncology* 25 (2023), p. 100408.

[86] Jun Ma et al. “Segment anything in medical images”. In: *Nature Communications* 15.1 (2024), p. 654.

[87] Hallee E. Wong et al. “ScribblePrompt: Fast and Flexible Interactive Segmentation for Any Biomedical Image”. In: *European Conference on Computer Vision (ECCV)* (2024).

[88] Yufan He et al. “VISTA3D: Versatile Imaging SegmenTation and Annotation model for 3D Computed Tomography”. In: *arXiv preprint arXiv:2406.05285* (2024).

[89] Yuxin Du et al. “Segvol: Universal and interactive volumetric medical image segmentation”. In: *Advances in Neural Information Processing Systems* 37 (2024), pp. 110746–110783.

[90] Haoyu Wang et al. “Sam-med3d: towards general-purpose segmentation models for volumetric medical images”. In: *European Conference on Computer Vision*. Springer. 2025, pp. 51–67.

[91] Andres Diaz-Pinto et al. “DeepEdit: Deep editable learning for interactive segmentation of 3D medical images”. In: *MICCAI Workshop on Data Augmentation, Labelling, and Imperfections*. Springer. 2022, pp. 11–21.

[92] Fabian Isensee et al. “nnInteractive: Redefining 3D Promptable Segmentation”. In: *arXiv preprint arXiv:2503.08373* (2025).

[93] Nicolas F Chaves-de-Plaza et al. “Towards fast human-centred contouring workflows for adaptive external beam radiotherapy”. In: *Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2022 Annual Conference*. 2022, pp. 111–131.

[94] Gregory Sharp et al. “Vision 20/20: Perspectives on automated image segmentation for radiotherapy”. In: *Med Phys* 41 (2014), pp. 1–13. URL: <https://doi.org/10.1118/1.4871620>..

[95] Charlotte L. Brouwer et al. “CT-based delineation of organs at risk in the head and neck region: DAHANCA, EORTC, GORTEC, HKNPCSG, NCIC CTG, NCRI, NRG Oncology and TROG consensus guidelines”. In: *Radiother Oncol* 117 (2015), pp. 83–90. URL: <https://doi.org/10.1016/j.radonc.2015.07.041>.

[96] Charlotte L. Brouwer et al. “3D Variation in delineation of head and neck organs at risk”. In: *Radiat Oncol* 7.1 (2012). URL: <https://doi.org/10.1186/1748-717X-7-32>.

[97] J. J. Stelmes et al. “Quality assurance of radiotherapy in the ongoing EORTC 1420 “Best of” trial for early stage oropharyngeal, supraglottic and hypopharyngeal carcinoma: results of the benchmark case procedure”. In: *Radiat Oncol* 16 (2021), pp. 1–10. URL: <https://doi.org/10.1186/s13014-021-01809-2>.

[98] Ellen J.L. Brunnenberg et al. “External validation of deep learning-based contouring of head and neck organs at risk”. In: *Phys Imaging Radiat Oncol* 15 (2020), pp. 8–15. URL: <https://doi.org/10.1016/j.phro.2020.06.006>.

[99] Curtise K.C. Ng, Vincent W.S. Leung, and Rico H.M. Hung. "Clinical Evaluation of Deep Learning and Atlas-Based Auto-Contouring for Head and Neck Radiation Therapy". In: *Appl Sci* 12 (2022). URL: <https://doi.org/10.3390/app122211681>.

[100] Michael V. Sherer et al. "Metrics to evaluate the performance of auto-segmentation for radiation treatment planning: A critical review". In: *Radiother Oncol* 160 (2021), pp. 185–191. URL: <https://doi.org/10.1016/j.radonc.2021.05.003>.

[101] Madalina Costea et al. "Comparison of atlas-based and deep learning methods for organs at risk delineation on head-and-neck CT images using an automated treatment planning system". In: *Radiother Oncol* 177 (2022), pp. 61–70. URL: <https://doi.org/10.1016/j.radonc.2022.10.029>.

[102] Madalina Costea et al. "Evaluation of different algorithms for automatic segmentation of head-and-neck lymph nodes on CT images". In: *Radiother Oncol* 188 (2023), p. 109870. URL: <https://doi.org/10.1016/j.radonc.2023.109870>.

[103] Landelijk Platform Radiotherapie Hoofd-halstumoren (LPRHHT) Landelijk Platform Protonentherapie (LPPT). *Landelijk Indicatie Protocol Protonentherapie (versie 2.2) (LIPPv2.2)*. https://nvro.nl/images/documenten/rapporten/2019-08-15_Landelijk_Indicatieprotocol_Protonentherapie_Hoofdhals_v2.2.pdf. 2019.

[104] Erik W Korevaar et al. "Practical robustness evaluation in radiotherapy – A photon and proton-proof alternative to PTV-based plan evaluation". In: *Radiother Oncol* 141 (2019), pp. 267–274. URL: <https://doi.org/10.1016/j.radonc.2019.08.005>.

[105] Ilma Xhaferllari et al. "Automated IMRT planning with regional optimization using planning scripts". In: *J Appl Clin Med Phys* 14 (2013), pp. 176–191. URL: <https://doi.org/10.1120/jacmp.v14i1.4052>.

[106] Stefan Speer et al. "Automation of radiation treatment planning". In: *Strahlentherapie Und Onkol* 193 (2017), pp. 656–665. URL: <https://doi.org/10.1007/s00066-017-1150-9>.

[107] Jose R Teruel et al. "Full automation of spinal stereotactic radiosurgery and stereotactic body radiation therapy treatment planning using Varian Eclipse scripting". In: *J Appl Clin Med Phys* 21 (2020), pp. 122–131. URL: <https://doi.org/10.1002/acm2.13017>.

[108] Wil M P Van Der Aalst, Martin Bichler, and Armin Heinzl. "Robotic Process Automation". In: *Business & Information Systems Engineering* 60 (2018), pp. 269–272. URL: <https://doi.org/10.1007/s12599-018-0542-4>.

[109] Andrzej Niemierko. "Reporting and analyzing dose distributions: A concept of equivalent uniform dose". In: *Med Phys* 24 (1997), pp. 103–110. URL: <https://doi.org/10.1118/1.598063>.

[110] Stanislav Nikolov et al. "Clinically Applicable Segmentation of Head and Neck Anatomy for Radiotherapy: Deep Learning Algorithm Development and Validation Study". In: *J Med Internet Res* 23 (2021), e26151. URL: <https://doi.org/10.2196/26151>.

[111] Xiaojin Gu et al. "Dose distribution prediction for head-and-neck cancer radiotherapy using a generative adversarial network: influence of input data". In: *Front. Oncol* 13 (2023), p. 1251132. URL: <https://doi.org/10.3389/fonc.2023.1251132>.

[112] Elizabeth M Jaworski et al. “Development and Clinical Implementation of an Automated Virtual Integrative Planner for Radiation Therapy of Head and Neck Cancer”. In: *Adv Radiat Oncol* 8 (2023), p. 101029. URL: <https://doi.org/10.1016/j.adro.2022.101029>.

[113] Rachel Petragallo et al. “Barriers and facilitators to clinical implementation of radiotherapy treatment planning automation : A survey study of medical dosimetrists”. In: *Journal of Applied Clinical Medical Physics* 23 (2022), pp. 1–10. URL: <https://doi.org/10.1002/acm2.13568>.

[114] Johannes A. Langendijk et al. “National protocol for model-based selection for proton therapy in head and neck cancer”. In: *Int J Part Ther* 8 (2021), pp. 354–365. URL: <https://doi.org/10.14338/IJPT-20-00089.1>.

[115] Mei Ling Yap et al. “Global access to radiotherapy services: have we made progress during the past decade?” In: *Journal of global oncology* 2.4 (2016), pp. 207–215.

[116] Vijay Badrinarayanan, Alex Kendall, and Roberto Cipolla. “Segnet: A deep convolutional encoder-decoder architecture for image segmentation”. In: *IEEE transactions on pattern analysis and machine intelligence* 39.12 (2017), pp. 2481–2495.

[117] Tyler LaBonte, Carianne Martinez, and Scott A Roberts. “We Know Where We Don’t Know: 3D Bayesian CNNs for Credible Geometric Uncertainty”. In: *arXiv preprint arXiv:1910.10793* (2019).

[118] Chuan Guo et al. “On calibration of modern neural networks”. In: *International Conference on Machine Learning*. PMLR. 2017, pp. 1321–1330.

[119] Jishnu Mukhoti and Yarin Gal. “Evaluating Bayesian Deep Learning Methods for Semantic Segmentation”. In: *CoRR* abs/1811.12709 (2018). arXiv: [1811.12709](https://arxiv.org/abs/1811.12709). URL: <http://arxiv.org/abs/1811.12709>.

[120] Yarin Gal. “Uncertainty in deep learning”. In: (2016).

[121] K Kian Ang et al. “Randomized phase III trial of concurrent accelerated radiation plus cisplatin with or without cetuximab for stage III to IV head and neck carcinoma: RTOG 0522”. In: *Journal of clinical oncology* 32.27 (2014), p. 2940.

[122] Jie Hu, Li Shen, and Gang Sun. “Squeeze-and-excitation networks”. In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2018, pp. 7132–7141.

[123] Maoke Yang et al. “Denseaspp for semantic segmentation in street scenes”. In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2018, pp. 3684–3692.

[124] Yarin Gal and Zoubin Ghahramani. “Dropout as a bayesian approximation: Representing model uncertainty in deep learning”. In: *international conference on machine learning*. PMLR. 2016, pp. 1050–1059.

[125] Yeming Wen et al. “Flipout: Efficient Pseudo-Independent Weight Perturbations on Mini-Batches”. In: *International Conference on Learning Representations (ICLR)*. 2017. eprint: 1803.04386 (cs.LG).

[126] Fausto Milletari, Nassir Navab, and Seyed-Ahmad Ahmadi. “V-net: Fully convolutional neural networks for volumetric medical image segmentation”. In: *2016 fourth international conference on 3D vision (3DV)*. IEEE. 2016, pp. 565–571.

[127] Saeid Asgari Taghanaki et al. “Combo loss: Handling input and output imbalance in multi-organ segmentation”. In: *Computerized Medical Imaging and Graphics* 75 (2019), pp. 24–33.

[128] Martín Abadi et al. *TensorFlow: Large-Scale Machine Learning on Heterogeneous Systems*. Software available from tensorflow.org. 2015. URL: <https://www.tensorflow.org/>.

[129] W Jeffrey Zabel et al. “Clinical evaluation of deep learning and atlas-based auto-contouring of bladder and rectum for prostate radiation therapy”. In: *Practical Radiation Oncology* 11.1 (2021), e80–e89.

[130] Lisanne V Van Dijk et al. “Improving automatic delineation for head and neck organs at risk by Deep Learning Contouring”. In: *Radiotherapy and Oncology* 142 (2020), pp. 115–123.

[131] Charlotte L Brouwer et al. “Assessment of manual adjustment performed in clinical practice following deep learning contouring for head and neck organs at risk in radiotherapy”. In: *Physics and imaging in radiation oncology* 16 (2020), pp. 54–60.

[132] Rachel Petragallo et al. “Barriers and facilitators to clinical implementation of radiotherapy treatment planning automation: A survey study of medical dosimetrists”. In: *Journal of Applied Clinical Medical Physics* 23.5 (2022), e13568.

[133] Nicolas F Chaves-de-Plaza et al. “Towards fast human-centred contouring workflows for adaptive external beam radiotherapy”. In: *Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2022 Annual Conference*. 2022.

[134] Wenhui Lei et al. “DeepIGeoS-V2: deep interactive segmentation of multiple organs from head and neck images with lightweight CNNs”. In: *Large-Scale Annotation of Biomedical Data and Expert Label Synthesis and Hardware Aware Learning for Medical Imaging and Computer Assisted Intervention: International Workshops, LABELS 2019, HAL-MICCAI 2019, and CuRIOS 2019, Held in Conjunction with MICCAI 2019, Shenzhen, China, October 13 and 17, 2019, Proceedings* 4. Springer. 2019, pp. 61–69.

[135] Bhavani Sambaturu et al. “ScribbleNet: Efficient interactive annotation of urban city scenes for semantic segmentation”. In: *Pattern Recognition* 133 (2023), p. 109011.

[136] Ananya Kumar, Percy S Liang, and Tengyu Ma. “Verified uncertainty calibration”. In: *Advances in Neural Information Processing Systems* 32 (2019).

[137] Ranganath Krishnan and Omesh Tickoo. “Improving model calibration with accuracy versus uncertainty optimization”. In: *Advances in Neural Information Processing Systems* (2020).

[138] Jize Zhang, Bhavya Kailkhura, and T Yong-Jin Han. “Mix-n-match: Ensemble and compositional methods for uncertainty calibration in deep learning”. In: *International conference on machine learning*. PMLR. 2020, pp. 11117–11128.

[139] Sebastian Gruber and Florian Buettner. “Better uncertainty calibration via proper scores for classification and beyond”. In: *Advances in Neural Information Processing Systems* 35 (2022), pp. 8618–8632.

[140] A Philip Dawid. “The well-calibrated Bayesian”. In: *Journal of the American Statistical Association* 77.379 (1982), pp. 605–610.

[141] Jishnu Mukhoti and Yarin Gal. “Evaluating Bayesian Deep Learning Methods for Semantic Segmentation”. In: *CoRR* abs/1811.12709 (2018). arXiv: [1811.12709](https://arxiv.org/abs/1811.12709).

[142] Yeming Wen et al. “Flipout: Efficient pseudo- independent weight perturbations on mini-batches”. In: *Proceedings of the 6th International Conference on Learning Representations*. 2018.

[143] Prerak Mody et al. “Improving Error Detection in Deep Learning Based Radiotherapy Autocontouring Using Bayesian Uncertainty”. In: *Uncertainty for Safe Utilization of Machine Learning in Medical Imaging: 4th International Workshop, UNSURE 2022, Held in Conjunction with MICCAI 2022*. 2022. ISBN: 978-3-031-16748-5.

[144] Yarin Gal. “Uncertainty in Deep Learning”. In: *PhD Thesis, University of Cambridge* (2016).

[145] Chuan Guo et al. “On calibration of modern neural networks”. In: *International conference on machine learning*. PMLR. 2017, pp. 1321–1330.

[146] Gabriel Pereyra et al. “Regularizing neural networks by penalizing confident output distributions”. In: *arXiv preprint arXiv:1701.06548* (2017).

[147] Rafael Müller, Simon Kornblith, and Geoffrey E Hinton. “When does label smoothing help?” In: *Advances in neural information processing systems* 32 (2019).

[148] Jishnu Mukhoti et al. “Calibrating deep neural networks using focal loss”. In: *Advances in Neural Information Processing Systems* 33 (2020), pp. 15288–15299.

[149] Balamurali Murugesan et al. “Calibrating segmentation networks with margin-based label smoothing”. In: *Medical Image Analysis* 87 (2023), p. 102826.

[150] Charlotte L Brouwer et al. “3D variation in delineation of head and neck organs at risk”. In: *Radiation Oncology* 7.1 (2012), pp. 1–10.

[151] Shi Hu et al. “Supervised uncertainty quantification for segmentation with multiple annotations”. In: *Medical Image Computing and Computer Assisted Intervention–MICCAI 2019: 22nd International Conference, Shenzhen, China, October 13–17, 2019, Proceedings, Part II* 22. Springer. 2019, pp. 137–145.

[152] Eli Gibson et al. “Artificial Intelligence with Statistical Confidence Scores for Detection of Acute or Subacute Hemorrhage on Noncontrast CT Head Scans”. In: *Radiology: Artificial Intelligence* 4.3 (2022), e210115.

[153] Yarin Gal and Zoubin Ghahramani. “Dropout as a Bayesian approximation: Representing model uncertainty in deep learning”. In: *International conference on machine learning*. PMLR. 2016, pp. 1050–1059.

[154] Li Wan et al. “Regularization of neural networks using dropconnect”. In: *International conference on machine learning*. PMLR. 2013, pp. 1058–1066.

[155] Charles Blundell et al. “Weight uncertainty in neural network”. In: *International conference on machine learning*. PMLR. 2015, pp. 1613–1622.

[156] Roger D Soberanis-Mukul, Nassir Navab, and Shadi Albarqouni. “Uncertainty-based graph convolutional networks for organ segmentation refinement”. In: *Medical Imaging with Deep Learning*. PMLR. 2020, pp. 755–769.

[157] Andres Diaz-Pinto et al. “DeepEdit: Deep Editable Learning for Interactive Segmentation of 3D Medical Images”. In: *Data Augmentation, Labelling, and Imperfections: Second MICCAI Workshop, DALI 2022, Held in Conjunction with MICCAI 2022*. Springer. 2022, pp. 11–21.

[158] Zhipeng Ding et al. “Local temperature scaling for probability calibration”. In: *Proceedings of the IEEE/CVF International Conference on Computer Vision*. 2021, pp. 6889–6899.

[159] Yaniv Ovadia et al. “Can you trust your model’s uncertainty? evaluating predictive uncertainty under dataset shift”. In: *Advances in neural information processing systems* 32 (2019).

[160] Balamurali Murugesan et al. “Trust your neighbours: Penalty-based constraints for model calibration”. In: *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer. 2023, pp. 572–581.

[161] Tsung-Yi Lin et al. “Focal loss for dense object detection”. In: *Proceedings of the IEEE international conference on computer vision*. 2017, pp. 2980–2988.

[162] Christian Szegedy et al. “Rethinking the inception architecture for computer vision”. In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016, pp. 2818–2826.

[163] Bingyuan Liu et al. “The devil is in the margin: Margin-based label smoothing for network calibration”. In: *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2022, pp. 80–88.

[164] Bingyuan Liu et al. “Class adaptive network calibration”. In: *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2023, pp. 16070–16079.

[165] Sunil Thulasidasan et al. “On mixup training: Improved calibration and predictive uncertainty for deep neural networks”. In: *Advances in neural information processing systems* 32 (2019).

[166] Davood Karimi et al. “Accurate and robust deep learning-based segmentation of the prostate clinical target volume in ultrasound images”. In: *Medical image analysis* 57 (2019), pp. 186–196.

[167] Jeremy Nixon et al. “Measuring Calibration in Deep Learning.” In: *CVPR workshops*. Vol. 2. 7. 2019.

[168] Max-Heinrich Laves et al. “Well-calibrated model uncertainty with temperature scaling for dropout variational inference”. In: *arXiv preprint arXiv:1909.13550* (2019).

[169] Biraja Ghoshal and Allan Tucker. *On Calibrated Model Uncertainty in Deep Learning*. 2022. URL: <https://europepmc.org/article/PPR/PPR517139>.

[170] Zijie Chen et al. “A novel hybrid convolutional neural network for accurate organ segmentation in 3D head and neck CT images”. In: *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer. 2021, pp. 569–578.

[171] Saeid Asgari Taghanaki et al. “Combo loss: Handling input and output imbalance in multi-organ segmentation”. In: *Computerized Medical Imaging and Graphics* 75 (2019), pp. 24–33.

[172] Michael Yeung et al. “Unified focal loss: Generalising dice and cross entropy-based losses to handle class imbalanced medical image segmentation”. In: *Computerized Medical Imaging and Graphics* 95 (2022), p. 102026.

[173] Prerak P Mody et al. “Comparing Bayesian models for organ contouring in head and neck radiotherapy”. In: *Medical Imaging 2022: Image Processing*. Vol. 12032. SPIE. 2022, pp. 100–109.

[174] K Kian Ang et al. “Randomized phase III trial of concurrent accelerated radiation plus cis-platin with or without cetuximab for stage III to IV head and neck carcinoma: RTOG 0522”. In: *Journal of clinical oncology* 32.27 (2014), p. 2940.

[175] Xianghua Ye et al. “Comprehensive and clinically accurate head and neck cancer organs-at-risk delineation on a multi-institutional study”. In: *Nature Communications* 13.1 (2022), p. 6137.

[176] Anneke Meyer et al. “Anisotropic 3D multi-stream CNN for accurate prostate segmentation from multi-planar MRI”. In: *Computer Methods and Programs in Biomedicine* 200 (2021), p. 105821.

[177] Michela Antonelli et al. “The medical segmentation decathlon”. In: *Nature communications* 13.1 (2022), p. 4128.

[178] Geert Litjens et al. “Evaluation of prostate segmentation algorithms for MRI: the PROMISE12 challenge”. In: *Medical image analysis* 18.2 (2014), pp. 359–373.

[179] Paul J Doolan et al. “A clinical evaluation of the performance of five commercial artificial intelligence contouring systems for radiotherapy”. In: *Frontiers in oncology* 13 (2023), p. 1213068.

[180] Gerd Heilemann et al. “Clinical implementation and evaluation of auto-segmentation tools for multi-site contouring in radiotherapy”. In: *Physics and Imaging in Radiation Oncology* 28 (2023), p. 100515.

[181] Young Woo Kim, Simon Biggs, and Elizabeth Claridge Mackonis. “Investigation on performance of multiple ai-based auto-contouring systems in organs at risks (oars) delineation”. In: *Physical and Engineering Sciences in Medicine* 47.3 (2024), pp. 1123–1140.

[182] Lee Goddard et al. “Evaluation of multiple-vendor AI autocontouring solutions”. In: *Radiotherapy Oncology* 19.1 (2024), p. 69.

[183] Prerak Mody et al. “Improving Uncertainty-Error Correspondence in Deep Bayesian Medical Image Segmentation”. In: *Machine Learning for Biomedical Imaging* 2 (August 2024 issue 2024), pp. 1048–1082. ISSN: 2766-905X. DOI: <https://doi.org/10.59275/j.melba.2024-5gc8>. URL: <https://melba-journal.org/2024:018>.

[184] Michael J Trimpl et al. “Deep learning-assisted interactive contouring of lung cancer: Impact on contouring time and consistency”. In: *Radiotherapy and Oncology* 200 (2024), p. 110500.

[185] Douwe J Spaanderman et al. “Minimally interactive segmentation of soft-tissue tumors on CT and MRI using deep learning”. In: *European Radiology* (2024), pp. 1–10.

[186] Mathis Ersted Rasmussen et al. “A simple single-cycle interactive strategy to improve deep learning-based segmentation of organs-at-risk in head-and-neck cancer”. In: *Physics and Imaging in Radiation Oncology* 26 (2023), p. 100426.

[187] Zixiang Wei et al. “An Interactive Deep-Learning Workflow for Head and Neck Gross Tumour Volume Segmentation”. In: *Available at SSRN* 5219763 (2025).

[188] Julie van der Veen, Akos Gulyban, and Sandra Nuyts. “Interobserver variability in delineation of target volumes in head and neck cancer”. In: *Radiotherapy and Oncology* 137 (2019), pp. 9–15.

[189] M Jorge Cardoso et al. “Monai: An open-source framework for deep learning in healthcare”. In: *arXiv preprint arXiv:2211.02701* (2022).

[190] Heleen Bollen, Akos Gulyban, and Sandra Nuyts. “Impact of consensus guidelines on delineation of primary tumor clinical target volume (CTVp) for head and neck cancer: Results of a national review project”. In: *Radiotherapy and Oncology* 189 (2023), p. 109915.

[191] Hugo Pereira, Luis Romero, and Pedro Miguel Faria. “Web-Based DICOM Viewers: A Survey and a Performance Classification”. In: *Journal of Imaging Informatics in Medicine* (2024), pp. 1–19.

[192] Bill Lubanovic. *FastAPI*. “O'Reilly Media, Inc.”, 2023.

[193] Sébastien Jodogne. “The Orthanc ecosystem for medical imaging”. In: *Journal of digital imaging* 31.3 (2018), pp. 341–352.

[194] Ron Kikinis, Steve D Pieper, and Kirby G Vosburgh. “3D Slicer: a platform for subject-specific image analysis, visualization, and clinical support”. In: *Intraoperative imaging and image-guided therapy*. Springer, 2013, pp. 277–289.

[195] napari contributors. *napari: a multi-dimensional image viewer for Python*. url<https://doi.org/10.5281/zenodo.3555620>. 2019. DOI: [10.5281/zenodo.3555620](https://doi.org/10.5281/zenodo.3555620).

[196] Constantin Ulrich et al. “RadioActive: 3D Radiological Interactive Segmentation Benchmark”. In: *CoRR* (2024).

[197] Junlong Cheng et al. “Interactive medical image segmentation: A benchmark dataset and baseline”. In: *Proceedings of the Computer Vision and Pattern Recognition Conference*. 2025, pp. 20841–20851.

[198] May Abdel-Wahab et al. “Global radiotherapy: current status and future directions—white paper”. In: *JCO global oncology* 7 (2021), pp. 827–842.

[199] Hongcheng Zhu et al. “Global radiotherapy demands and corresponding radiotherapy-professional workforce requirements in 2022 and predicted to 2050: a population-based study”. In: *The Lancet Global Health* 12.12 (2024), e1945–e1953.

[200] Mark J Gooding et al. “Fully automated radiotherapy treatment planning: A scan to plan challenge”. In: *Radiotherapy and Oncology* 200 (2024), p. 110513.

[201] Dylan Callens et al. “Is full-automation in radiotherapy treatment planning ready for take off?” In: *Radiotherapy and Oncology* (2024), p. 110546.

[202] Stanislav Nikolov et al. “Deep learning to achieve clinically applicable segmentation of head and neck anatomy for radiotherapy”. In: *ArXiv e-prints* (2018). arXiv: [1809.04430 \[cs.CV\]](https://arxiv.org/abs/1809.04430). URL: <https://arxiv.org/abs/1809.04430>.

[203] Young Woo Kim, Simon Biggs, and Elizabeth Claridge Mackonis. “Investigation on performance of multiple ai-based auto-contouring systems in organs at risks (oars) delineation”. In: *Physical and Engineering Sciences in Medicine* 47.3 (2024), pp. 1123–1140.

[204] Prerak Mody et al. “Large-scale dose evaluation of deep learning organ contours in head-and-neck radiotherapy by leveraging existing plans”. In: *Physics and Imaging in Radiation Oncology* 30 (2024), p. 100572.

[205] Jishnu Mukhoti and Yarin Gal. “Evaluating bayesian deep learning methods for semantic segmentation”. In: *arXiv preprint arXiv:1811.12709* (2018).

[206] Alex Kendall and Yarin Gal. “What Uncertainties Do We Need in Bayesian Deep Learning for Computer Vision?” In: *Advances in Neural Information Processing Systems*. Ed. by I. Guyon et al. Vol. 30. Curran Associates, Inc., 2017. URL: <https://proceedings.neurips.cc/paper/2017/file/2650d6089a6d640c5e85b2b88265dc2b-Paper.pdf>.

[207] Alex Kendall, Vijay Badrinarayanan, and Roberto Cipolla. “Bayesian segnet: Model uncertainty in deep convolutional encoder-decoder architectures for scene understanding”. In: *arXiv preprint arXiv:1511.02680* (2015).

[208] Agustinus Kristiadi, Matthias Hein, and Philipp Hennig. “Being bayesian, even just a bit, fixes overconfidence in relu networks”. In: *International conference on machine learning*. PMLR. 2020, pp. 5436–5446.

[209] Andrew YK Foong et al. “‘In-Between’Uncertainty in Bayesian Neural Networks”. In: *arXiv preprint arXiv:1906.11537* (2019).

[210] Aryan Mobiny et al. “Dropconnect is effective in modeling uncertainty of bayesian deep networks”. In: *Scientific reports* 11.1 (2021), p. 5458.

[211] Alex Kendall and Yarin Gal. “What uncertainties do we need in Bayesian deep learning for computer vision?” In: *Advances in neural information processing systems* 30 (2017).

[212] Fabian Isensee et al. “nnU-Net: a self-configuring method for deep learning-based biomedical image segmentation”. In: *Nature methods* 18.2 (2021), pp. 203–211.

[213] Tomaž Vrtovec et al. “Auto-segmentation of organs at risk for head and neck radiotherapy planning: from atlas-based to deep learning methods”. In: *Medical physics* 47.9 (2020), e929–e950.

[214] Olaf Ronneberger, Philipp Fischer, and Thomas Brox. “U-net: Convolutional networks for biomedical image segmentation”. In: *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015*. Springer. 2015, pp. 234–241. URL: https://doi.org/10.1007/978-3-319-24574-4_28.

[215] Wentao Zhu et al. “Anatomynet: Deep 3d squeeze-and-excitation u-nets for fast and fully automated whole-volume anatomical segmentation”. In: *BioRxiv* (2018), p. 392969.

[216] Carlos E Cardenas et al. "Head and neck cancer patient images for determining auto-segmentation accuracy in T2-weighted magnetic resonance imaging through expert manual segmentations". In: *Medical physics* 47.5 (2020), pp. 2317–2322.

[217] Valentin Oreiller et al. "Head and neck tumor segmentation in PET/CT: the HECKTOR challenge". In: *Medical image analysis* 77 (2022), p. 102336.

[218] Johannes A Langendijk et al. "Selection of patients for radiotherapy with protons aiming at reduction of side effects: the model-based approach". In: *Radiotherapy and Oncology* 107.3 (2013), pp. 267–273.

[219] Lisa Van den Bosch et al. "Comprehensive toxicity risk profiling in radiation therapy for head and neck cancer: A new concept for individually optimised treatment". In: *Radiotherapy and Oncology* 157 (2021), pp. 147–154.

[220] *Scripting in Raystation.* <https://www.raysearchlabs.com/siteassets/about-overview/media-center/wp-re-ev-n-pdfs/white-papers/white-paper-5---scripting-aug-20152.pdf>.

[221] *Scripting in Raystation.* URL: <https://www.raysearchlabs.com/siteassets/about-overview/media-center/wp-re-ev-n-pdfs/white-papers/white-paper-5---scripting-aug-20152.pdf>.

[222] Michael J Trimpl et al. "Interactive contouring through contextual deep learning". In: *Medical Physics* 48.6 (2021), pp. 2951–2959.

[223] Alexander Kirillov et al. "Segment anything". In: *Proceedings of the IEEE/CVF International Conference on Computer Vision.* 2023, pp. 4015–4026.

[224] Yunyang Xiong et al. "Efficientsam: Leveraged masked image pretraining for efficient segment anything". In: *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition.* 2024, pp. 16111–16121.

[225] Douwe J Spaanderman et al. "Minimally interactive segmentation of soft-tissue tumors on CT and MRI using deep learning". In: *European Radiology* (2024), pp. 1–10.

[226] Hallee E Wong et al. "Scribbleprompt: fast and flexible interactive segmentation for any biomedical image". In: *European Conference on Computer Vision.* Springer. 2025, pp. 207–229.

[227] Sarbani Ghosh Laskar et al. "Access to radiation therapy: from local to global and equality to equity". In: *JCO global oncology* 8 (2022), e2100358.

List of publications

Journal articles

Mody, Prerak, Nicolas F. Chaves-de-Plaza, Chinmay Rao, Eleftheria Astrenidou, Mischa de Ridder, Nienke Hoekstra, Klaus Hildebrandt, and Marius Staring. "Improving Uncertainty-Error Correspondence in Deep Bayesian Medical Image Segmentation." *Machine Learning for Biomedical Imaging*, August 2024 issue (2024): 1048–82.
<https://doi.org/10.59275/j.melba.2024-5gc8>.

Mody, Prerak, Merle Huiskes, Nicolas F. Chaves-de-Plaza, Alice Onderwater, Rense Lamsma, Klaus Hildebrandt, Nienke Hoekstra, Eleftheria Astreinidou, Marius Staring, and Frank Dankers. "Large-scale dose evaluation of deep learning organ contours in head-and-neck radiotherapy by leveraging existing plans." *Physics and Imaging in Radiation Oncology* 30 (2024): 100572.

Chaves-de-Plaza, Nicolas F., **Prerak Mody**, Marius Staring, René van Egmond, Anna Vilanova, and Klaus Hildebrandt. "Inclusion depth for contour ensembles." *IEEE Transactions on Visualization and Computer Graphics* 30, no. 9 (2024): 6560-6571.

Chaves-de-Plaza, Nicolas F., Mathijs Molenaar, **Prerak Mody**, Marius Staring, René van Egmond, Elmar Eisemann, Anna Vilanova, and Klaus Hildebrandt. "Depth for Multi-Modal Contour Ensembles." *Computer Graphics Forum*, vol. 43, no. 3, p. e15083. 2024.

Jia, Jingnan, Bo Yu, **Prerak Mody**, Maarten K. Ninaber, Anne A. Schouffoer, Jeska K. de Vries-Bouwstra, Lucia JM Kroft, Marius Staring, and Berend C. Stoel. "Using 3D point cloud and graph-based neural networks to improve the estimation of pulmonary function tests from chest CT." *Computers in Biology and Medicine* 182 (2024): 109192.

Chaves-de-Plaza, Nicolas F., **Prerak Mody**, Klaus Hildebrandt, Marius Staring, Eleftheria Astreinidou, Mischa de Ridder, Huib de Ridder, Anna Vilanova, and René van Egmond. "Implementation of delineation error detection systems in time-critical radiotherapy: Do AI-supported optimization and human preferences meet?." *Cognition, Technology & Work* (2024): 1-17.

Mody, Prerak, Nicolas Chaves de Plaza, Mark Gooding, Martin de Jong, Mischa de Ridder, Niels den Hans, Jos Elbers, Klaus Hildebrandt, Marius Staring. "Manual Brush vs AI Pencil: Evaluating tools for auto-contour refinement of head-and-neck tumors on CT+PET". *Submitted* (2025).

Gao, Ruochen, **Prerak Mody**, Chinmay Rao, Frank Dankers, and Marius Staring. "On factors that influence deep learning-based dose prediction of head and neck tumors." *Physics in Medicine & Biology* 70, no. 11 (2025): 115006.

International conference proceedings

Mody, Prerak, Nicolas F. Chaves-de-Plaza, Klaus Hildebrandt, and Marius Staring. "Improving error detection in deep learning based radiotherapy autocontouring using Bayesian uncertainty." *International Workshop on Uncertainty for Safe Utilization of Machine Learning in Medical Imaging*, pp. 70-79. Cham: Springer Nature Switzerland, 2022.

Chaves-de-Plaza, Nicolas F, **Prerak Mody**, Klaus Hildebrandt, Marius Staring, Eleftheria Astreinidou, Mischa de Ridder, Huib de Ridder, and René van Egmond. "Towards fast human-centred contouring workflows for adaptive external beam radiotherapy." *Proceedings of the Human Factors and Ergonomics Society Europe* (2022): 111-31.

Mody, Prerak P, Nicolas Chaves-de-Plaza, Klaus Hildebrandt, René van Egmond, Huib de Ridder, and Marius Staring. "Comparing Bayesian models for organ contouring in head and neck radiotherapy." *Medical Imaging 2022: Image Processing*, vol. 12032, pp. 100-109. SPIE, 2022.

Tan, Yicong, **Prerak Mody**, Viktor van der Valk, Marius Staring, and Jan van Gemert. "Analyzing components of a transformer under different dataset scales in 3D prostate CT segmentation." *Medical Imaging 2023: Image Processing*, vol. 12464, pp. 49-60. SPIE, 2023.

Open source software

Mody, Prerak, Koning, Patrick. "A terminal user interface (TUI) to view the status of your SLURM cluster." *online at <https://pypi.org/project/slurm-viewer/>* (2024).

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Curriculum Vitae

Prerak was born in Mumbai, Maharashtra province, India in 1993. He finished his high school studies at Arya Vidya Mandir, Mumbai, India in 2011. He obtained a Bachelors of Technology (B.Tech) degree in Computer Science and Engineering at Vellore Institute of Technology (VIT), India in 2015. His masters studies (MSc) in Computer Science was done at Technical University (TU) Delft, Netherlands from 2018-2020. The topic of the masters thesis at Philips, Netherlands was on 3D human pose estimation in privacy preserving settings (for e.g. using point cloud images).

Shortly after he started his PhD at Division of Image Processing (LKEB), Radiology, Leiden University Medical Center with a focus on human-centered techniques for contouring in radiotherapy. Since 2025 he works at Medis Medical Imaging building software solutions to detect coronary structures within CT scans using deep learning.