The current and future role of automation in radiotherapy treatment planning

Ibragim M Bamatov¹ and Dzhabrail M Bamatov ²

¹ FGBOU VO "Chechen State University", 32, Sheripova str., Grozny, 364024, Russia
² Head of the Centre Collective Usage, Grozny State Oil Technical University named after Academician M. D. Millionshchikov, Prospekt Kh. Isayeva, 100, Grozny, 364061, Russia

E-mail: ibragim-1991@mail.ru

Abstract. The aim of the project was to investigate what is the current and future roles of automation in radiotherapy treatment planning. The existing articles on the topic suggest that currently this area is progressively becoming semi-automated. Where the existing systems estimate what are the desirable dose distributions and suggest certain recommendations as how to achieve those limits of dose distribution. Whereas in the future, many believe that the treatment planning process will become fully automated. From end-to-end starting from the first simulation of radiotherapy and actual treatment itself no human intervention will be present. Although, there are no evidence to state what the treatment planning systems would look like exactly, it cannot be denied that the automation of the process will only be increasing, it is just it cannot be predicted to what degree it will be done so for now.

1. Introduction
There are different types treatment planning techniques that can be used for different radiotherapy modalities accordingly. Each technique used enhances a certain aspect for the treatment while sacrificing something else. A study was done comparing the influence of 4 different treatment planning techniques in breast conserving therapy, namely conventional tangential technique (Tan), forward planned IMRT (fIMRT), inverse planned IMRT (iIMRT) and VMAT. The study showed that the Tan provided adequate dose coverage but resulted in high dose absorption by healthy tissue, fIMRT and iIMRT had significantly better conformity and high dose volume reduction than Tan, VMAT provided nearly ideal dose homogeneity and conformity, however the low-dose volume increased to a dangerous degree [1].

High level intervention of a treatment planner in the radiotherapy treatment planning can lead to unreliability in the quality of the treatment plan and the efficiency of how the plans are produced depending on the skills and experience of the planner involved [2, 3].

There are 13 minor steps to be taken to plan the radiation therapy treatment process. The steps can be seen in figure 1.
Recent studies have shown that patients are put at risk when sub-par treatment plans are used in clinical trial. The mortality rates for common cancer diagnoses are drastically higher in developing countries. One of the major reasons for that is stated to be the professional level of the treatment planning team or the lack of a fully automated treatment planning solution [5].

Treatment planning automation can be achieved through the smart use of self-learning programming better known as “artificial intelligence” on various aspects of the treatment planning [6].
It can be done using different approaches to the database, for example the planning either being knowledge based, atlas based, multi-criteria based etc. [7, 8] Image segmentation also can be done using different techniques, for example threshold method, edge-based method etc. [9].

Currently there are many debates among the scientific circle on the topic of fully automated radiotherapy treatment planning. One side state that fully automated radiotherapy treatment planning is unavoidable, some even predict it to happen by as early as 2025. Whereas, others claim that fully automated treatment planning systems will not be used at all, even when the technological development does allow it [10].

Automation is a very important aspect in radiotherapy treatment planning. It can reduce the time required to produce a treatment plan, while decreasing variability and increasing quality and as consequence, saving lives even more effectively. It is very important to understand the current state of automation in the radiotherapy treatment planning and what is the future role it can play after further optimisation of the process.

2. Current Role of Automation in radiotherapy treatment planning

Even though the state-of-the-art in radiotherapy treatment planning has not reached the point where it is fully automated, it cannot be denied that the automation is continuously more implemented. However, there are still many optimisations to be done to the existing systems. The commercial software that today's market can offer will only produce a 1-D dose-volume histogram (DVH) values based on a model historical clinical knowledge. The general idea is to estimate the lowest dose for organs at risk and compare the achieved dose of treatment plan with the predictions. The model is optimised based on the clinical data of patient's geometry and possible dose distributions. The results serve as a guideline during the process of treatment planning, giving the general idea of what is dosimetrically achievable and what is not [11].

The dose distribution estimation made automation a necessity in the earlier computerised treatment planning period. Nowadays, even more complicated tasks are automated. For instance, image registration, organ delineation and dose optimisation. In a sense, it is possible to fully create, evaluate and document a treatment plan with almost no external intervention of a planner. However, radiation oncology still relies on distribution of tasks shared among medical and technical stuff. Even if the people involved are highly skilled professionals, procedures can become prone to human error, that sometimes even lead to lethal outcome [12].

The current role of automation in the treatment planning in radiotherapy is such that the process is vastly becoming semi-automated. Using historical knowledge based and computer aided optimisations, the human factor variability is being removed.

3. Future role of Automation in radiotherapy treatment planning

There are still many areas that require automation in the treatment planning of radiotherapy. Ideally, many suggest that the treatment planning should be automated to the point where it's done from end-to-end. They predict that all the steps between the first radiotherapy treatment simulation and actual treatment are to be done without the need of human intervention. It means that a universal auto-segmentation platform is to be created that can identify not only all the forms of anatomical structures across all imaging modalities, it will also be able to perfectly include every patient's individual clinical circumstances into a fully automated tumour contour volume contouring [10].

On the other hand, there are some studies suggesting that statistically there is no dependence on the technological parameters. Nelms in his study on treatment plan quality of planners and planning systems states that the variation in plan quality can be attributed to a category that can be itself continuously improved, where best practice would be to increase the mean quantity of planners population (both human and planning systems), to improve the mean quality of the treatment plan and to minimize any variation in it.

Many planners fear that with the invention of the fully automated planning systems, their jobs would be at risk, however such a pessimistic view should not be very possible. The first records of
such fears are dated back to 1950, and almost 70 years from then, the job loss did not actually come to be the reality. It should be noted that the optimistic views also did not hold to be true. Similarly, many believe that even though, their jobs may experience some form of modernisation, they are not very likely to be fired [11].

Overall, it can be said that the treatment planning process in radiotherapy will definitively become more automated, however the degree to which it will be done is still a question of debate. Within the last few years there has been a significant progress in the research and development in the industry [2]. However, the existing paper do not allow yet to surely state what would look like the treatment planning systems exactly.

4. Conclusion
In conclusion, radiotherapy treatment planning becomes more and more depended on automation. This work aimed to overview what is the current role of automation in treatment planning of radiotherapy, and what is the future role for it the scientists predict to take, and to see if there are any positive and negative prediction. Currently, the treatment planning is becoming semi-automated, where humans in combination automated treatment planning systems work together to produce the most beneficial treatment plan achievable. This includes image registration, organ delineation and dose optimisation done by automation systems, whereas manually the steps done are plan evaluation, plan approval, plan implementation, treatment verification. However, many still view the human factor that is prone to error as a risk, and of opinion that fully automated treatment planning systems are to be created. Majority suggest that the future of automation in radiotherapy treatment planning is that the process will become fully automated to the point where starting from the first radiotherapy treatment simulation (treatment directive) and going to the actual treatment itself are to be done without the need of human intervention. On the other hand, there are those who say that the process will never be fully automated and human experts will still be needed to control and take care of the systems. However, the existing research done today does not allow to state what it would look like exactly and the future role is not yet to be clear, as automation does not solve problems just by itself.

Reference
[1] Supakalin N, Pesee M et al. 2018 Comparision of Different Radiotherapy Planning Techniques for Breast Cancer after Breast Conserving Surgery Asian Pacific Journal of Cancer Prevention 19 2929-34
[2] Mohammad H, Ben J M, Dirk V and Nisbet A 2018 Automation in intensity-modulated radiotherapy treatment planning - a review of recent innovations British Institute of Radiology 91 1091
[3] Ibragim Bamatov, Rumyantsev E and Bamatov D 2019 The modification of temperature control at each stage of V-star continuous flow reactor Journal of Physics: Conference Series 1399
[4] Van Dyk J and Rosenwald J 2006 IAEA Technical Reports Series No. 430: Commissioning and Quality Assurance of Computerized Planning Systems for Radiation Treatment of Cancer Medical Physics 33(2)
[5] Jemal A, Miller K D and Siegel R L 2018 A Cancer Journal for Clinicians Cancer statistics 68(1) 7-30
[6] McIntosh C, Welch M et al. 2016 Fully Automated Treatment Planning for Head and Neck Radiotherapy using a Voxel-Based Dose Prediction and Dose Mimicking Method Physics in Medicine and Biology 62(15)
[7] Shang Q, Shen Z L et al. 2015 Evolution of treatment planning techniques in external-beam radiation therapy for head and neck cancer Applied Radiation Oncology
[8] Bamatov I, Rumyantsev E and Bamatov D 2019 Development of the chemical reactor V-star for continuous flow reactions IOP Conference Series: Materials Science and Engineering 537
[9] Kaur D et al 2014 International Journal of Computer Science and Mobile Computing 3(5) 809-
Orton C G 2014 Within the next 10 years treatment planning will become fully automated without the need for human intervention *Medical Physics* **41**(12) 120601 1-4

Matthew F M 2018 *Topics in Cancer Radiotherapy: Automated Treatment Planning and Quality Assurance* (University of California San Diego) pp 4-17

Nelms B E, Robinson G *et al.* 2012 Variation in external beam treatment plan quality: An interinstitutional study of planners and planning systems *Pract. Radiat. Oncol* **2** 299-305