Using artificial intelligence (AI) to make radiotherapy in children more precise

- **Children's bodies are still developing and are very sensitive to radiation**
- **AI improves scans taken during radiotherapy, to ensure precise dose delivery to the treatment area**
- **Less radiation dose to normal tissues minimises the risk of side effects of the treatment**

Adam Szmul[1], Catarina Veiga[1], Lisa Whittaker[2], Holly Spencer[3], Steve Oliver[3], Jagdish Bains[3], Katharine Gignac[3] and Gill Brown[4]. ([1] cancer researcher, [2] engagement facillitator, [3] patient representative, [4] graphic designer)

What is radiotherapy?

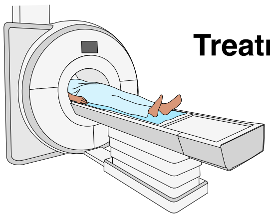
Radiotherapy is a very effective treatment used in about half of all people diagnosed with cancer. Radiation is used to damage cancer cells but can also damage healthy cells in the area being treated.

Before a patient starts treatment, the radiotherapy team has to calculate the dose of radiation a patient needs and exactly where they need it. The aim is to give a high dose of radiation to the cancer cells, while reducing the dose to the surrounding healthy tissues and reducing the risk of side effects.

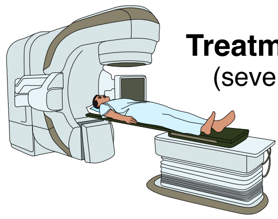
A week or two before treatment begins patients have a 'planning imaging scan', which will be used by the clinical team to plan their treatment.

When a patient arrives for each session of their treatment, they may have a 'treatment imaging scan' to verify if they are well positioned for treatment and to check for changes in the patient's body. Typically the 'treatment imaging scans' are not as clear and sharp as the 'planning imaging scans'.

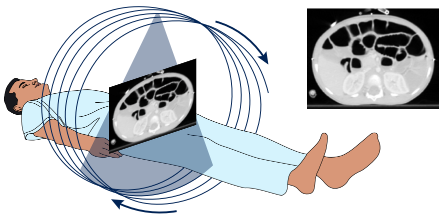
Treatment planning



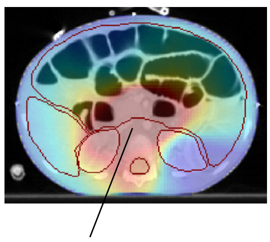
Treatment delivery
(several sessions)



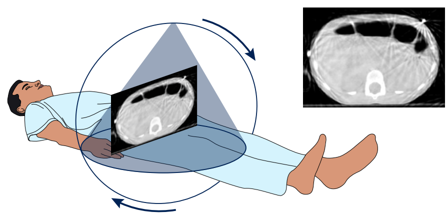
Diagnosis → Planning imaging scan → Planning the radiotherapy dose → Treatment imaging scans → **Follow-up**



The machines that take the 'planning imaging scan' operate by repeatedly rotating around the patient while shooting narrow X-ray beams.



The dark red region is the treatment area.



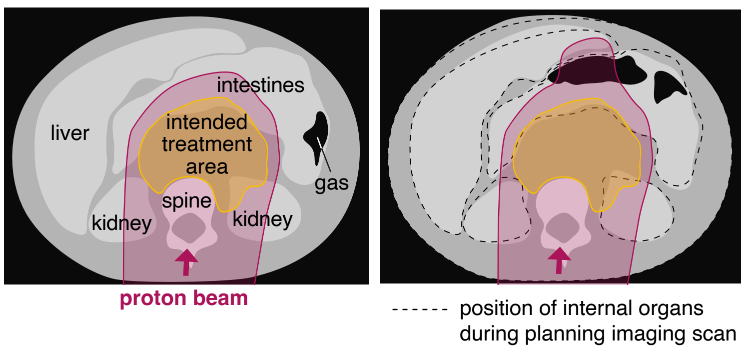
The radiotherapy treatment machines have their own imaging system that uses a broader cone-shaped X-ray beam and rotates only once around the patient.

What is the clinical problem we are trying to solve?

Our research focused on radiotherapy in the abdomen of children. Day-to-day changes in the abdomen, such as variations in the contents of the bowel, gas and organ movements, mean it is challenging to make sure the radiotherapy is precisely delivered at every treatment session. Some types of radiotherapy, such as proton beam therapy, are more affected by bodily changes.

One solution commonly used is to treat a larger area to make sure the intended target is always getting the correct dose. This also increases the dose delivered to healthy tissues, meaning a higher risk of side effects. A better option is to take more imaging scans during treatment, so that any internal bodily changes can be monitored and the radiotherapy treatment can be adapted accordingly. To do this, we need 'treatment imaging scans' of better quality. Artificial Intelligence (AI) can support this process.

Planned dose | **Treatment delivery dose**



This diagram shows a simple example of bodily changes between the 'planning' and the radiotherapy 'treatment' session. These differences in the contents of the intestines may result, for example, in an additional unwanted dose to healthy organs like the liver.

What did we do?

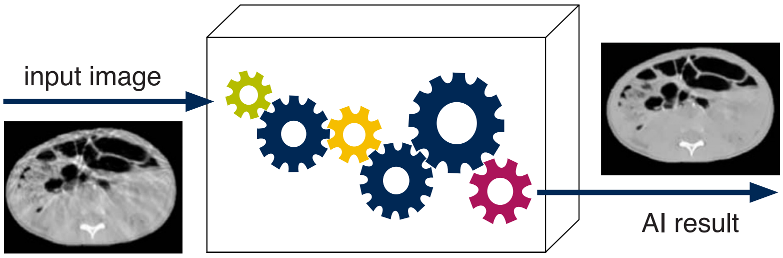
We used AI to generate a better quality version of the 'treatment imaging scans' which can be used to monitor and adapt the delivery of radiotherapy treatments.

The key to AI development is a process called training, where a computer program is given a large amount of data (sometimes with labels explaining what the data is) and a set of instructions. The program will then learn to recognise patterns in the data based on the instructions, for example, "find all the images containing faces". It might need some nudging along the way (such as "that's not a face") but what the program learns from the data, and the clues it is given, becomes the AI model.

In our research, we started with a well-established AI method and improved it further to make the quality of the 'treatment imaging scans' clearer and sharper.

Our improved AI method

Our way to improve the AI method was to give it three nudges during training, as follows:



We carefully selected and prepared the images used by the AI method during training, which allowed us to deal with some of the unique challenges of learning from children's images.

We asked the AI method to not modify the bodily structures that can be seen in the input images.

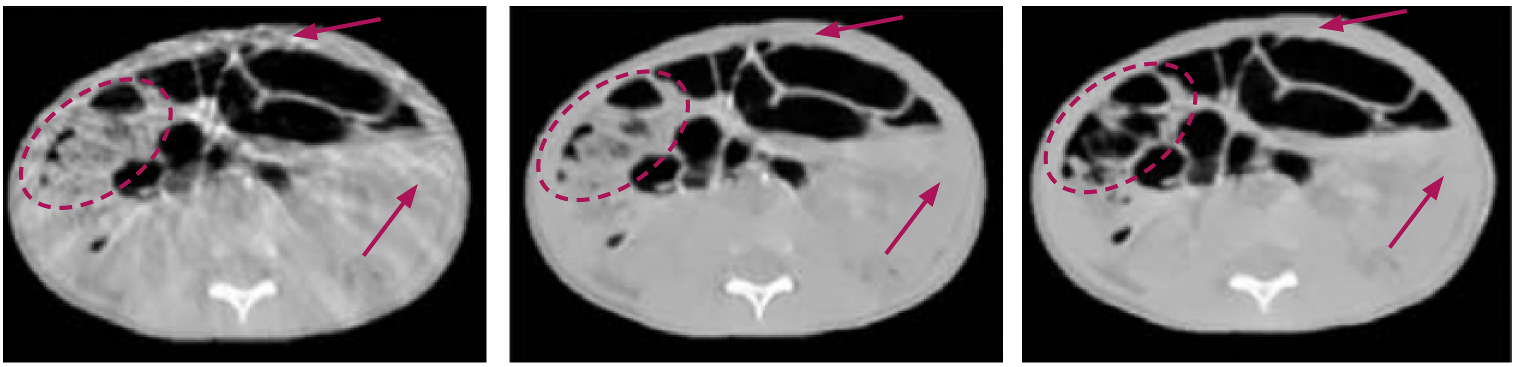
We trained the AI method to simply learn the differences between the input image and its new, better quality version.

Our results

Here is an example of how a 'treatment imaging scan' of the abdomen has been improved using our method.

Our method generates the improved images in just a few seconds, resulting in no delay to the treatment session.

Input image | **AI result with our improvements** | **AI result without our improvements**



Our improved AI results are much sharper and clearer than the input 'treatment imaging scans'.

Our improved AI results better preserve the bodily structures, where previous methods would have changed the contents of the bowel.

What have we achieved so far and what are the next steps?

Our AI method improves the 'treatment imaging scans' for children with cancers in their abdomen.

By publishing our work we are sharing what we found with others who may want to build on our research.

We will now seek further funding to see if our method could be used with other patients or in clinical studies.

Ultimately, our aim is to make a difference to the lives of those affected by cancer.

Want to find out more details about our work? Scan the QR code or go to: iopscience.iop.org/article/10.1088/1361-6560/acc921

Want to know more about radiotherapy? Scan the QR code or go to the radiotherapy pages of the Cancer Research UK website: www.cancerresearchuk.org/about-cancer/treatment/radiotherapy

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