Mathematical program helps doctors perform more efficient radiosurgery

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Jean-Philippe Thiran and Marc Levivier. Credit: EPFL

Engineers at EPFL and local startup Intuitive Therapeutics have developed software that can produce optimized surgical plans for Gamma Knife radiosurgery. Doctors at the Lausanne University Hospital (CHUV) began using the software in July.

Radiosurgery is a kind of radiotherapy where doctors administer a high

dose of radiation to diseased tissue with extreme precision, and in one go rather than over several sessions. Used mainly to treat brain damage, this method can prevent the need for conventional surgery on patients suffering from benign tumors, vascular malformation, neuralgia and Parkinson's disease. Radiosurgery can be performed using a device called the Gamma Knife, which is able to administer gamma rays from up to 192 different beams. The challenge is to make sure the radiation hits only the diseased tissue and none of the healthy tissue around it—while keeping the procedure as short as possible.

The plans for this type of surgery are usually drawn up manually; neurosurgeons work with radio-oncologists and physicians to select the number, size, shape and power of the beams to be used and map out exactly where they should be directed so that the entire treatment area is covered. How effective the plans are therefore depends largely on the doctors' experience. To take that out of the equation, Intuitive Therapeutics set out to develop software that can calculate all of the criteria automatically. The startup began working with Professor Jean-Philippe Thiran at EPFL's Signal Processing Laboratory 5 (LTS5) in 2015, and together they developed a program called IntuitivePlan, which is currently available on the market.

Using mathematics to improve healthcare

IntuitivePlan uses an optimal inverse planning system whereby doctors specify the radiation dose to be applied to each area of the diseased tissue as well as the maximum dose that the surrounding tissue can be exposed to. Based on these inputs, the software generates a surgical plan that optimizes the various criteria along with a preprogrammed constraint on how long the procedure should last, so as to minimize patients' overall exposure time. "Developing the surgical plans involves a process of combinatorial optimization that is computationally expensive by nature. The calculation method we chose is called convex

optimization," says Thiran.

The program uses powerful processing techniques that can generate the optimal combination in under two minutes. "It takes 20 or 30 minutes to develop a plan manually—sometimes even longer for complicated procedures," says Professor Marc Levivier, head of neurosurgery at the CHUV and director of the CHUV's Gamma Knife Center. Levivier is one of the world's top Gamma Knife experts. "The software often comes up with plans that we never would have thought of ourselves, or wouldn't have been able to map out by hand," he says. IntuitivePlan doesn't just save time by automating the process—it also results in better plans.

Promising initial results

The engineers at Intuitive Therapeutics were able to turn their original idea into a complete software program designed specifically to meet doctors' needs. And now that their program has obtained the CE Marking, it can be used in routine clinical procedures. Doctors at the CHUV started using the new approach in July. "I trust the program fully, but for the first few procedures I also created some surgical plans by hand, and compared them with those produced by the software. Then I selected the best option for each patient. The initial results have been very promising," says Levivier.

For now, IntuitivePlan is compatible only with Gamma Knife devices, but the engineers are already working on adapting their program to other kinds of radiotherapy equipment.

More information: Marc Levivier et al. A real-time optimal inverse planning for Gamma Knife radiosurgery by convex optimization: description of the system and first dosimetry data, *Journal of Neurosurgery* (2019). DOI: 10.3171/2018.7.GKS181572

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