Master thesis in Applied Maths
ROI and dynamic reconstruction in tomography*

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In a CT scanner, the tissue attenuation function $\mu : \mathbb{R}^2 \to \mathbb{R}$ is measured in a slice from the attenuation of X-rays emmitted from a source at $\vec{v}(t)$, where $\vec{v}(t), t \in T$, is the trajectory of the source point around the patient.

$$\begin{array}{rccc} \vec{v} \ : & T \subset \mathbb{R} & \longrightarrow & \mathbb{R}^2 \\ & t & \longrightarrow & \vec{v}(t) \end{array}$$

The circle is the most simple source trajectory (in modern CT scanners, the source trajectory is helical and the reconstruction problem is then 3D). The Fan Beam projections are defined by

$$g\left(\vec{v}_t, \alpha\right) = \int_0^{+\infty} \mu\left(\vec{v}_t + l\vec{\zeta}(\alpha)\right) dl \tag{1}$$

with $\vec{\zeta}(\alpha) = (\cos\alpha, \sin\alpha), \alpha \in [0, 2\pi)$ the unitary direction of the integration line (X-ray beam), see Fig 1. The complete fonction μ can be reconstructed by non truncated projections g from a circular trajectory since the sixties. The trajectory must be sufficient (all points in the support of f must be measured from all directions and the projections $g\left(\vec{v}_t, \alpha\right)$ have to be non-truncated in α). Region of Interest (ROI) can be reconstructed only since 2002 [4, 1] from partial (truncated) projections and trajectories.

In medical applications, surgeons are using mobile radiological systems (C-arm) in the Operating Room for intervention planning, control and guiding, see Fig. 1. The C-arm systems can be used in order to perform a ROI reconstruction of the patient in the OR.

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1. First C-arm system are slow, thus some movements of the patient can not be neglected. The attenuation function $\mu(t, \vec{x})$ depends on the time. We can assume that $\mu(t, \vec{x})$ is in the form $\mu\left(\vec{\Gamma}_t(\vec{x})\right)$, where μ is an attenuation reference (for example at $t = 0$), and $\vec{\Gamma}_t : \mathbb{R}^2 \longrightarrow \mathbb{R}^2$ ($\mathbb{R}^3$ in 3D) is a diffeomorphism depending on the time t. We have proposed [3, 2] analytical methods to compensate for deformations preserving the acquisition lines geometry.
2. Second (and more critic), C-arm detectors are too small for complete projections of the thorax region in the OR for a circular trajectory. Thus ROI reconstruction must be considered.

The aim of this master project is to combine ROI reconstruction and analytic compensation of dynamic deformations in tomography.

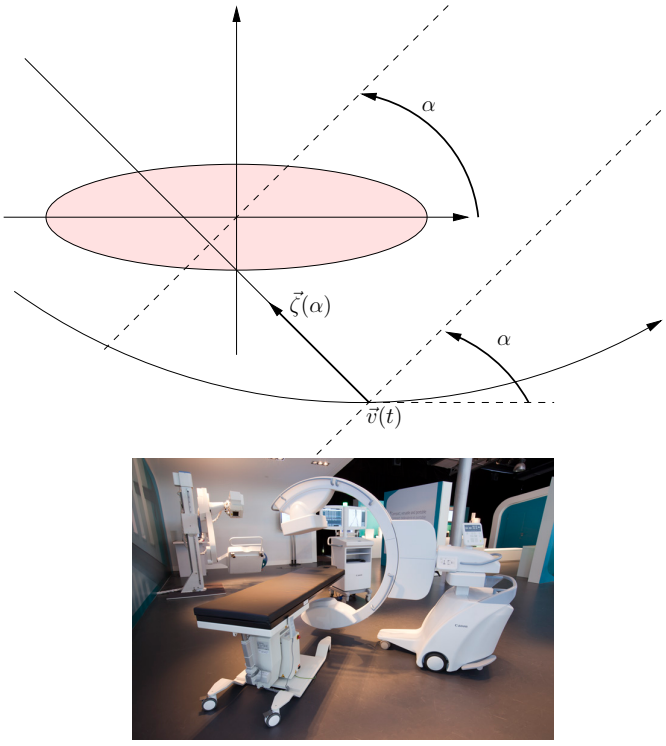

FIGURE 1 – Left : Fan Beam geometry variables (t, α). Right : C-Arm systems for the OR.

Références

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