

Question 4

- Here is our Google search question again. You know of the applications of tomography in medicine (CT scanning) and virology/structural biology. Your job is to search for a journal paper from any other field which requires the use of tomographic reconstruction (examples: seismology, agriculture, gemology). State the title, venue and year of publication of the paper. State the mathematical problem defined in the paper. Take care to explain the meaning of all key terms clearly. State the method of optimization that the paper uses to solve the problem. [16 points]

Answer:

- Title: Ultrasound Transmission Tomography for Detecting and Measuring Cylindrical Objects Embedded in Concrete
- Journal name: Sensors (open access journal on the science and technology of sensors)
- Year of publication: 2017
- Authors: Lluveras Núñez, D.; Molero-Armenta, M.Á.; Izquierdo, M.Á.G.; Hernández, M.G.; Anaya Velayos
- Field: Civil structures and materials, Structural engineering

Brief Summary of the paper:

The paper explores the reconstruction of concrete using ultrasound attenuation tomography. The reconstruction is based on the attenuation of ultrasound signal. In the field of seismic tomography, travel time tomography is a common method. In travel time tomography, the travel time of a seismic signal is measured. The travel time of a seismic signal is the time it takes for the signal to travel from the source to the receiver. However, in attenuation tomography, along with the travel time, attenuation of elastic waves is also utilized for tomographic reconstruction. It is also stated that attenuation is vital for characterizing properties of rock and fluid because attenuation is more sensitive than velocity to some of the material condition properties, such as saturation, porosity, permeability and viscosity. The paper also evaluates the performance of ultrasound transmission based on attenuation to locate and estimate the most common materials that are embedded in concrete, reinforcements and natural and artificial voids. The paper uses fan tomographic inspection that considers the discretization of the attenuation spatial-distribution as shown below

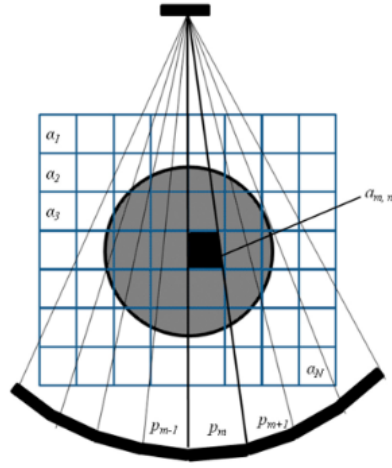


Figure 1. Fan tomographic inspection that considers the discretization of the attenuation spatial-distribution.

Mathematical Problem:

Typically, the inverse problem solved in attenuation tomography is the following:

$$p = A\alpha$$

where, p is the measurement vector, α is the vector that contains the discretized values of the attenuation spatial-distribution, and A is the matrix describing the linear relation. Since, the problem is ill-posed the inverse problem is solved using the iterative method. The iterative method is based on algebraic reconstruction methods update the solution by successively processing each equation (ray) separately. The process can be mathematically described by

$$\alpha^{k+1} = \alpha^k + \lambda \frac{p_{(k+1)} - a_{(k+1)}^T \alpha^k}{\|a_{(k+1)}\|^2} a_{(k+1)}$$

where $a_{(k+1)}$ is the $(k + 1)$ th row of the matrix A . The relaxation parameter is denoted by λ which varies between 0 and 1. The above mentioned iterative algorithm is also known as SIRT (Simultaneous Iterative Reconstruction Technique). In SIRT based ray-trace methodology, propagation of wave is based on Hyugen's principle

The experimental results in the paper showed that using a high-performance automatic ultrasonic inspection system the tomographic images are very useful for evaluating the internal inclusions of concrete structures. It was shown that the attenuation tomographic images allow to locate and to estimate the size of the inclusion; however, it was not possible to determine the type of embedded material.