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Improvement of source localization technique in AE-Tomography

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1. INTRODUCTION

Acoustic Emission Tomography(AET) identifies the elastic wave velocity distribution by using only the arrival times of the elastic waves that is generated inside of the structures[1]. This technique intends that the elastic wave velocity distribution is identified by using Acoustic Emission(AE). AE is the elastic wave that occurs in the structures due to the occurrence of the cracks or friction of the exist cracks and the characteristic of AE is that the emitted location and emitted time of AE are unknown. The technique consists of two parts to identify the elastic wave velocity distribution by using AE. The first part is the source localization and the second part is the identification of the elastic wave velocity distribution on the basis of the estimated source locations that are identified in the first part of AET. Because of this computational procedure, the resultant elastic wave velocity distribution is affected by the quality of the source localization. However, the source localization is conducted on the initial elastic wave velocity distribution that is different from the actual elastic wave velocity distribution at the first trial, and consequently the identified source locations involves the error caused by the difference between the initial and the actual elastic wave velocity distributions. The error of the identified source locations on the first stage affects to the identified elastic wave velocity distribution at the end of the first step, and the second stage starts on the identified elastic wave velocity distribution. Since the second step starts on the identified elastic wave velocity distribution and the distribution, the source localization is performed on the elastic wave velocity distribution at the first step, and the source locations at the second step is improved in comparison with the source locations at the first step. Then the resultant elastic wave velocity distribution at the second step is improved as well. This procedure is iteratively performed, and it is expected that the resultant source locations and elastic wave velocity distribution are improved step by step.

However, the influence of the error of the initial elastic wave velocity distribution still remains after the steps, and the resultant elastic wave velocity distribution may not be close to the real elastic wave velocity distribution sufficiently. For overcoming this problem, improvement of the computational procedure is required. Therefore, in this study, an improvement of the source localization technique is proposed, and the validity of the proposed technique is discussed.

2. METHODOLOGY

Figure 1 shows the conceptual flow diagram of AET. The computational procedure of AET is similar to Elastic wave velocity tomography. Generally, the initial elastic wave velocity distribution is given at first, then theoretical first travel times between the excitation and the sensor are computed, and elastic wave velocity distribution is reconstructed by using an identification technique in Elastic wave velocity tomography. However, the location and the time of the excitation of AE are unknown although these are necessary to compute the first travel times. Thus, the location and the time are estimated by using the source localization technique.

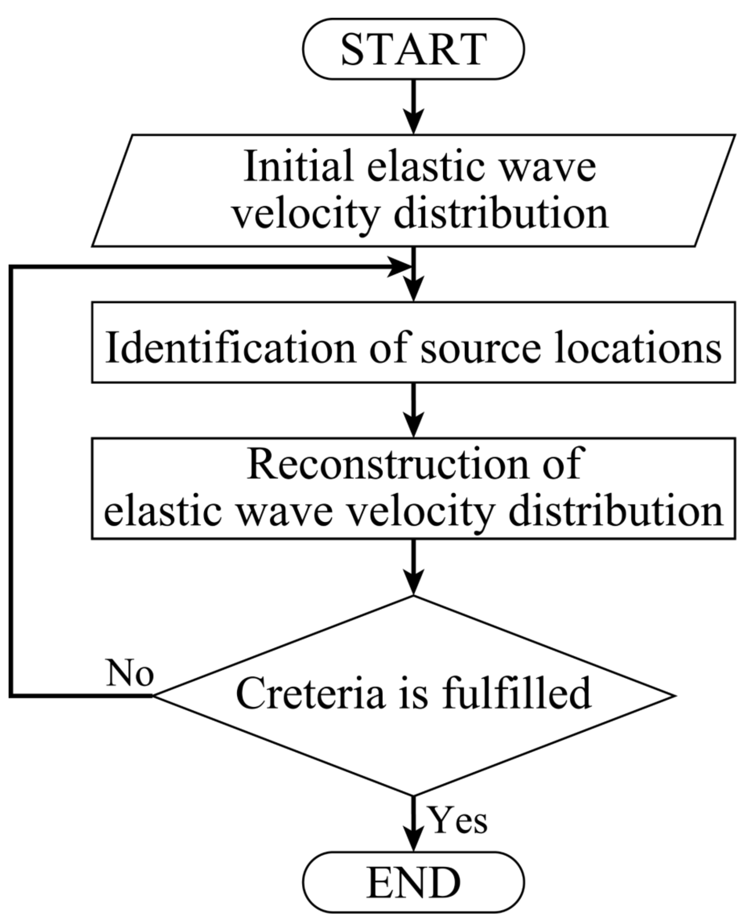

Figure 1 Conceptual flow diagram of AET

The source localization is implemented on the basis of the ray-trace technique in this study. In this study, the area of interest is meshed as illustrated in Figure 2. The ray-path is modeled as a polyline which apexes are located at the nodal points and the relay points on the mesh. The relay points are installed on the mesh to reduce the mesh dependency of the ray-path. The travel time between point *i* and point *j* on the mesh are computed as follows if the elastic wave velocity in each of the cells is uniform.

$$T_{ij} = \sum_{k=1}^{n} S_k l_k$$

in which T_{ij} is the travel time between point *i* and point *j*, S_k is the slowness of cell *k*, l_k is the length of the ray-path in cell *k*. This travel time is computed on all of the polylines between the two points and a polyline that gives minimum travel time is chosen as the ray-path of the first travel time. This ray-path is used to update the elastic wave velocity distribution at the identification procedure. The procedure of source localization uses this ray-path as well. If the arrival time at point *j* is A_j and an AE is emitted from point *i*, the AE should be emitted at

$$P_{ij} = A_j - T_{ij}$$

P_{ij} is potential emission time of AE. If and *m* sensors are installed on the mesh, each points has *m* potential emission times as consequence. If the elastic wave velocity distribution and

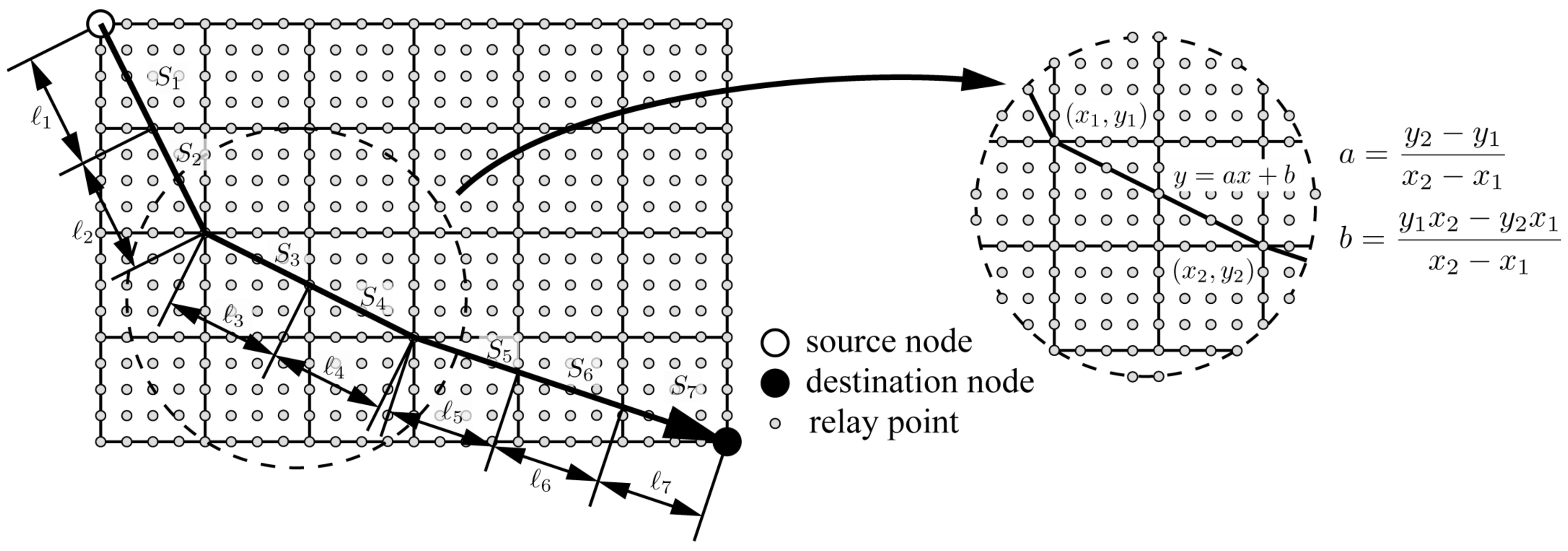

Figure 2 Mesh and ray-path

the computed ray-path are completely identical with the real elastic wave velocity distribution and the real ray-path and A_j does not involve any error, the *m* potential emission times are identical at the source location of AE. However, generally the elastic wave velocity distribution, the ray-path and the observed arrival times contains the errors and the point at where the *m* potential emission times are identical each other does not exits normally. Hence, the source location is determined as a point at where the variance of the potential emission times is minimum.

Since the variance of the potential emission times is affected by the elastic wave velocity distribution, the error occurs because of the difference of the elastic wave velocity distribution on which the source localization is performed and the initial elastic wave velocity distribution at the first iteration. If the low velocity area exists on the area of interest, the potential emission time that is computed by using the ray-path on the low velocity area become larger than the real emission time at the real source location. This relocates the identified source location to the further location as shown in Figure 3.

The elastic wave velocity distribution is identified by using this source locations of AE events and the resultant elastic wave velocity distribution sometimes is not very close to the real elastic wave velocity distribution. Thus, in this study, a technique to improve the accuracy of the source locations is proposed. The proposed technique improves the accuracy of the source locations by assessing the quality of the potential emission times at each points and ignores the inaccurate potential emission times while the computation of variance of the potential emission times. It is expected that the improvement raises the accuracy of the identified source locations and the quality of the resultant elastic wave velocity is improved as well.

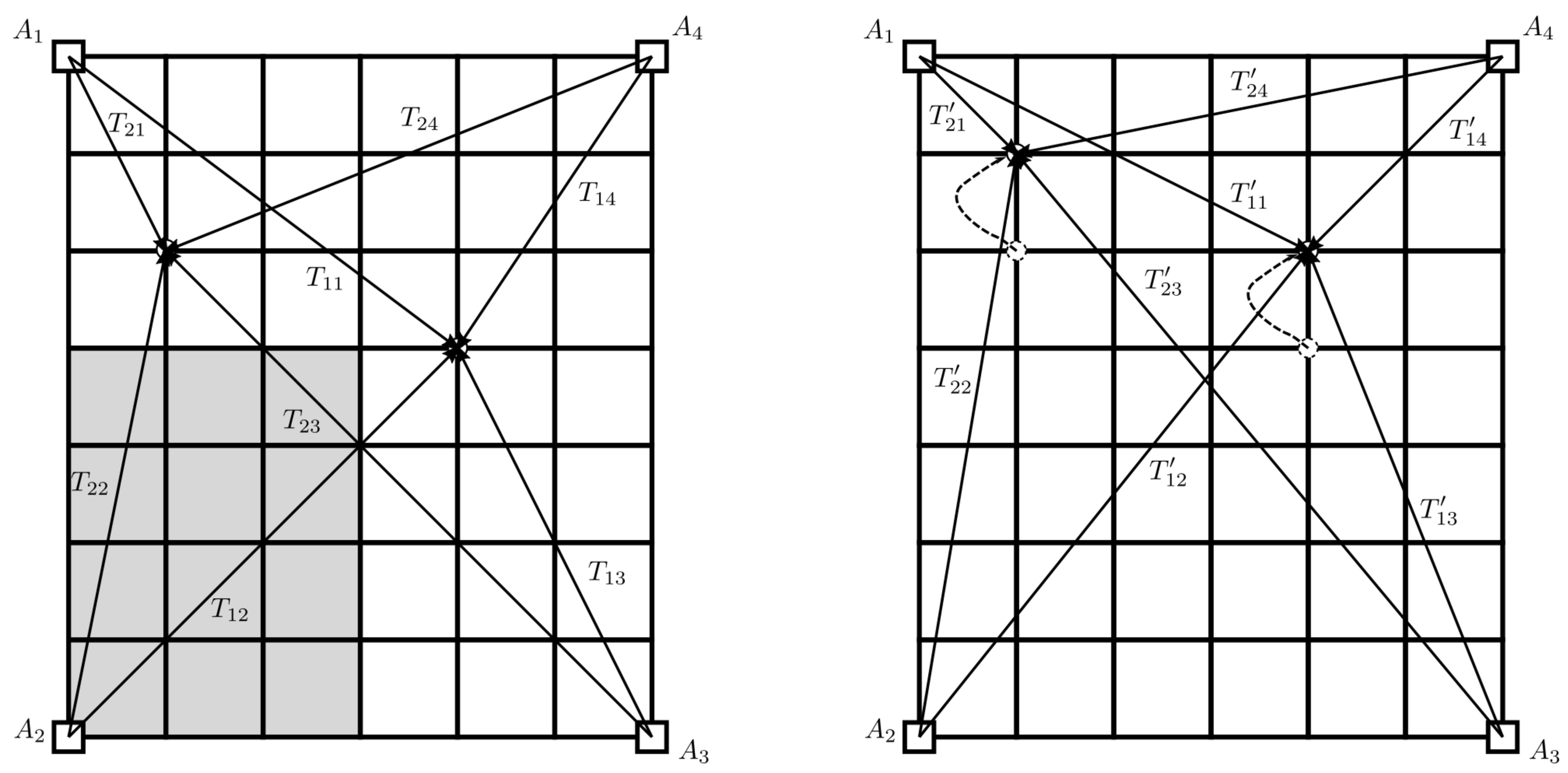

Figure 3 Change of source locations on different elastic wave velocity distribution
(Left: source locations on real elastic wave velocity distribution,
Right: source locations on initial elastic wave velocity distribution)

3. RESULT

The proposed technique is validated by performing a series of the numerical investigations. The results suggests that the accuracy of the source locations is improved if the damaged area locally exists in the area of interest. The result is introduced in the presentation in detail.

4. CONLUSIONS

The source localization technique based on Ray-trace technique is improved in this study by assessing the quality of the potential emission times. The proposed technique is validated by performing the series of numerical investigations. The following conclusions are obtained in this study.

1. The accuracy of the source localization is improved by adding the assessment of the potential emission times.

2. The proposed technique gives accurate elastic wave velocity distribution even if the area of interest is locally damaged severely.

References:

[1] Kobayashi Y., Shiotani T., Computerized AE Tomography, Innovative AE and NDT Techniques for On-Site Measurement of Concrete and Masonry Structures State-of-the-Art Report of the RILEM Technical Committee 239-MCM, Springer, 2016, pp.47-68.