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An Intelligent Assistant for Nuclear Test Ban Treaty Verification

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Abstract

This paper presents an intelligent assistant that filters seismic data from Norway's regional seismic array, NORESS, for underground nuclear weapons test ban treaty verification. Verification of a Comprehensive Test Ban Treaty or a Low Yield Threshold Test Ban Treaty places challenges on current seismic verification technology by lowering the magnitude of the seismic events that must be monitored, causing an exponential increase in the number of events detected. This task overwhelms seismic verification specialists, as each event must be analyzed to determine if it contains a clandestine nuclear test. The Seismic Event Analyzer Project in the Treaty Verification Research Group at Lawrence Livermore National Laboratory is concerned with the development of technologies for the automatic processing of seismic monitoring data. Here we discuss the single agent project.

Two important aspects of the intelligent assistant are (1) it acts as an assistant to the human analyst by filtering the large volume of continuously arriving data, presenting interpretations of "interesting" events for review, and (2) it emulates the problem solving behavior of the human seismic analyst using an Assumption Based Truth Maintenance System.

1 Introduction

The ultimate goal of seismic verification data processing research is to understand the issues of building a system to detect and locate events, discriminate between earthquakes and other seismic sources, and estimate yields of underground nuclear explosions. Here we focus on the seismic location problem, which may be used, in part, to classify the seismic event we are

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witnessing, and to provide information that constrains theories on possible evasive measures. The most reliable means available to verify compliance with treaties regulating underground nuclear weap-ons testing is seismic monitoring[1,2]. However, monitoring for a Comprehensive Test Ban Treaty (CTBT) or Low Yield Test Ban Treaty (LYTBT) increases the requirements on current verification technology.

To evade treaty provisions, nuclear tests would be designed to produce weak seismic signals. These low signal to noise ratio (SNR) events can be hidden in background noise or occur in conjunction with other seismic events. To address this problem sensor technologies offering lower detection levels and improved SNR must be used. However, lowering the detection threshold increases the number of events which must be examined. Our experience indicates up to 20,000 events a year may need to be analyzed from Norway's experimental seismic array, NORESS. Such events include earthquakes and chemical explosions as well as possible nuclear explosions. Each event must be analyzed to determine if it contained a clandestine nuclear test. There are few experts available for this type of interpretation problem. Therefore, reliable verification of a CTBT or LYTBT will require an automated system to help interpret and classify seismic events. Such a system, called SEA (Seismic Event Analyzer), is described in the remainder of this paper.

The following section gives an overview of the treaty verification research system at LLNL and motivates our intelligent systems approach to the problem of seismic interpretation. The next two sections examine the problem solving strategy used by seismologists and relate this strategy to belief revision. Subsequently, SEA's knowledge representation and assumption based reasoning schemes are presented. Finally, we describe our user interface, some of our implementation experiences, and answer the question, "Does it work?"

2 System Overview

SEA analyzes seismic data from the Norwegian experimental seismic array station, NORESS[3] . The geometry for the array, located in eastern Norway (about 100 Km north of Oslo) is shown in figure 1. SEA presently interprets data from 25 sensors deployed in four concentric rings, the largest being about 3 Km in diameter.

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As shown in Figure 2, we receive seismic data from Norway via satellite and archive it onto an optical disk. It is then processed by an event detection program which examines the raw sensor data for a possible seismic event. The event detector program generates an event