SURF 2003
LIGO Interferometer Data Analysis of Transients

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1 Introduction

The Laser Interferometer Gravitational-Wave Observatory (LIGO) project began construction in 1994. It consists of two identical facilities based at Hanford, Washington, and Livingston, Louisiana, both of which use laser interferometry to measure minute relative movements in two test masses at the end of 4km long vacuum tubes, arranged at right angles. From these measurements, and using sophisticated data processing and statistical analysis techniques, it is hoped observations of gravitational waves can be made.

The first scientific operation of LIGO took place in August 2002, alongside similar events at the GEO (European) and TAMA (Japanese) gravitational wave observatories. Further scientific operations are scheduled for February 14^{th} to April 14^{th}.

Dr. John Zweizig is currently involved in detector characterisation — the study of the operational performance of the LIGO interferometers. During operation of LIGO, the signals from the laser interferometers are first digitised, before being recorded electronically. Within these data, various transients occur, which could be due to either noise, or certain gravitational waves. The analysis and classification of these transients, and hopefully the elimination of noise transients, will form the basis of this SURF project.

2 Objectives

The objectives of this surf project are:

- To identify typical characteristics of individual signals and transients, in order to automatically detect such events.
- To produce software to implement analysis of LIGO data, using both those characteristics identified above, and other custom identifiers.
- To implement a filter in software through which to pass LIGO data, in order to eliminate known noise transients.
- Time permitting, to investigate using the above two tools other characteristics that may help identify transients or signals.

week 1	Familiarisation with LIGO and current data processing tools
week 2	Simple parameterisation of known transients
weeks 3–4	Program data analysis software using discovered characteristics
week 5	Testing of software on simulated and LIGO data
weeks 6–8	Investigation of better means of describing transients
week 9	Generation of filters for known categories
week 10	Project write-up

Table 1: A provisional timetable for this SURF project

3 Approach

Table 1 shows an estimated timetable for the project, although this will most likely be subject to considerable change, both before the project due to the experimental results obtained, and during the project due to unforeseen difficulties or new insights.

The first step would be to identify some simple properties of transients which have been located by other means in recent data. Once these are defined, construction of software to analyse data for these characteristics can begin. Using this software as a tool, further investigation into the properties of transients and other signals will be possible, whilst at the same time keeping the software updated. Using the software to analyse simple, simulated data would allow the program to be tested and its efficiency estimated. Towards the end of the SURF project, and based on the information gained from the software above, a software filter could be constructed to eliminate known noise transients from LIGO data.

The means of investigation will obviously depend on the results obtained from LIGO during the next four months. However, the following general areas will almost certainly play a central role:

Physical analysis of the physics of both gravitational waves and their method of detection, as well as noise introduced from other sources.

Statistical analysis of data obtained; for example, statistical modelling of noise, or significance testing of a given signal component.

Computational techniques for pattern matching and noise elimination, based on the results from the above analysis.