Template-Matching based Detection Algorithm user guide

This application detects in a continuous seismic signal a window that is similar to a provided template window (i.e. a portion of the signal that correlates with a value higher than an imposed threshold). Several steps are required in order to adequately run the program.

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REFERENCES Document Repository

CATEGORY Event Detection Algorithms

KEYWORDS Aftershocks, Earthquake Swarm, Data Selection

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Step by Step

The first thing that needs to be done in order to organize the data is to create two folders. The first one contains the template signal that we want to correlate. The second folder contains the continuous seismic data stream. You can create the folders as shown in the figure below.

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You can create a directory Template and a directory Continuous. At the end you should have your workspace like this one.

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E Template Continuous			

We will first add a template signal. In order to do this we will work with an example from SONG TRANH dataset. Select AH episodes and then SONG TRANH and click on **Events related waveforms**. We will add to the workspace the event 11. Just click on the event and add it to the workspace in the directory Template as shown in the figure below.

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Impactin	ng Factor 👻	SONG TRANH: deep water res ~	Seed Signal ~	Country ~ Start	End Q			
Results								
	▲ Name		Start	End	Data type			
	SONG_TRANH_signal000001	seed	2013 Aug 24 17:35:08	2013 Aug 24 17:38:12	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
0	SONG_TRANH_signal000002	.seed	2013 Aug 24 18:00:48	2013 Aug 24 18:03:52	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000003	l.seed	2013 Aug 24 18:00:52	2013 Aug 24 18:03:56	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000004	liseed	2013 Aug 28 17:37:40	2013 Aug 28 17:40:43	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE ¥
	SONG_TRANH_signal000005	iseed	2013 Aug 28 20:28:28	2013 Aug 28 20:31:33	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000006	iseed	2013 Aug 28 21:44:17	2013 Aug 28 21:47:21	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000007	seed	2013 Aug 29 18:07:59	2013 Aug 29 18:11:02	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🛩
	SONG_TRANH_signal000008	liseed	2013 Aug 29 18:08:47	2013 Aug 29 18:11:51	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000005	seed	2013 Aug 31 03:13:30	2013 Aug 31 03:16:35	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🛩
	SONG_TRANH_signal000010	l.seed	2013 Sep 02 00:26:06	2013 Sep 02 00:29:09	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
۲	SONG_TRANH_signal000011	seed	2013 Sep 03 00:07:48	2013 Sep 03 00:10:53	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000012	seed	2013 Sep 03 19:31:54	2013 Sep 03 19:34:56	Seed Signal	VIEW FILE	ADD TO WORKSRACE	MORE 🗸
	SONG_TRANH_signal000013	l.seed	2013 Sep 03 21:13:02	2013 Sep 03 21:16:07	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000014	iseed	2013 Sep 04 18:05:27	2013 Sep 04 18:08:31	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000015	seed	2013 Sep 04 19:49:43	2013 Sep 04 19:52:47	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000016	iseed	2013 Sep 04 19:51:46	2013 Sep 04 19:54:47	Seed Signal	VIEW FILE	ADD TO WORKSRACE	MORE 🗸
	SONG_TRANH_signal000017	seed	2013 Sep 04 20:05:53	2013 Sep 04 20:09:00	Seed Signal	VIEW FILE	ADD TO WORKSRACE	MORE 🗸
	SONG_TRANH_signal000018	l.seed	2013 Sep 04 20:09:21	2013 Sep 04 20:12:25	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000019	seed	2013 Sep 04 20:25:17	2013 Sep 04 20:28:21	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸
	SONG_TRANH_signal000020).seed	2013 Sep 05 01:08:02	2013 Sep 05 01:11:06	Seed Signal	VIEW FILE	ADD TO WORKSPACE	MORE 🗸

ADD SELECTED TO WORKSPACE

1 2 3 4 5 ... 348

We will now add the continuous dataset to the workspace. We need first to add to the workspace the **waveform download tool**. Add the tool to you workspace in the Continuous folder.

We will just extract the signal at 1 station and one channel (here in this example the channel HHZ of station TDVB). The continuous signal we want to analyse is from 2013 September 03 00:00:00 up to 2013 September 03 at 00:59:59. This is the maximum duration allowed to be processed by the waveform download tool program (60 minutes). This time period covers the time of the template itself so we can test to see if we recover the template waveform as detection. The following figure presents the extraction of this continuous waveform.

Time range	2013 Sep 03 00:00:	00	2013 Sep 03 00:59:59	Length	59	minutes
Episode	SONG TRANH: deep	water reservoir			•	
Channels		E	N 🗆 Z			
PHI: Phu	oc Hiep					
EHE	EHN	🗌 EHZ				
TNVB: Tr	a Nu					
📋 HHE	HHN	HHZ				
TMVB: Tr	a Mai					
□ HHE	HHN	🗌 HHZ				
TLVB: Tie	n Lanh					
HHE	🔲 HHN	HHZ				
TGI: Tra C	Siac					
🗌 EHE	EHN	🗌 EHZ	📋 HHE	HHN	🔲 HHZ	
TDVB: Tr	a Doc					
□ HHE	HHN	🕑 HHZ				
TLE: Tra I	leng					
🗌 EHE	EHN	EHZ	HHE	HHN	🔲 HHZ	
TNG: Tie	n Ngoc					
🗌 EHE	EHN	🗌 EHZ	📋 HHE	HHN	HHZ	
TBVB: Tra	a Bui					
HHE	HHN	🗌 HHZ				
DTDO: Tra	Don					
EHE	EHN	EHZ	📋 HHE	HHN	🔲 HHZ	
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We now need to convert the waveforms (template and continuous) in the SAC format in order to then run the Template matching code. In order perform this conversion simply add the **seed converter** program to the workspace.

In this application you can select the two seed files (templates and continuous). We will precise that we only want to convert the signal of station TDVB and channel HHZ into SAC waveforms. It will then produce two SAC files. The figure below shows the settings of the seed converter.

e SeedConverter	Description Converts SEED volume (either fullSEED or miniSEED) to either SAC or AS EXPAND	
NPUTS		
eed Waveform equired 1+	Template/SONG_TRANH_signal000011.seed Continuous/Waveform download/SONG_TRANH_20130903000000.se ed	CHANGE. CI
iter seismograms	No filtering Filter by station and channel Filter by channel orientation	
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lerge channels	<i>⊠</i> 0	
erging method	1 - 0	
ll value	Interpolate - 0	
utput file type	SAC •	

The two SAC files produced by the application are in this example VN.TDVB_HHZ.160000.SAC and VN.TDVB_HHZ.360000.SAC. The first one is the template file and the second one the continuous sac waveform. If you click on one of the waveform you can see the duration of the signal just to check which one is the template waveform and which one is the continuous data stream.

You need now to import to the workspace the Template Matching Detection application.

You need first to select the waveforms you want to use. Once you have selected your template waveform (called sac signal in the application) you will see it appearing in a window. You need to pick the P-wave arrival on this window; it will be used to define the portion of the template signal to correlate with the continuous signal.

This window will start at some fixed number of points before the P-wave pick and be of a given duration (both parameters can be set in the application). You also need to set the frequency range in which you want to filter both signals.

You also have to set the threshold correlation coefficient (between 0 and 1) such that only parts of the signal with correlation higher than this threshold will be considered as detections.

The last parameter that needs to be set is the minimum possible time between 2 detections. If two detections are less than this time, only the one with the highest correlation coefficient is kept. The figure below shows an example of setting the parameters for the signals we selected.

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File TemplateMatchingDetection	Description Detection of ev	vents by template matching. We will used a template data <u>EXPANE</u>	2
INPUTS			
Sac Signal Required 1 file	SeedConverter/VN.TDVBHHZ.160000.SAC		CHANGE CLEAR
Sac Waveform Required 1 file	SeedConverter/VN.TDVBHHZ.360000.SAC		CHANGE CLEAR
Pick points and phases: Name: VN.TDVBHHZ Samp	ng frequency: 100 [Hz] Samples #: 18356 Max value: 2	2.16E+6 [NM/5] ↔ + - 1 + - 3	Daseline correction Pick Point P V
		MMM	2.0E+6 10E+6 Applied 0.0E+0 -10E+6 -2.0E+6 -3.0E+6
00:08:20.700000 00:08:21.000000	00:08:21:00000 00:08:21:600000 00	08:21:900000 00:08:22:200000 00:08:22:5000 Time	00 00.08.22.800000 00.08.23.100000 Highcharts.com
Picked phases: -	east: 1		
Number of samples in the template window	512		
Number of points in the template window before the picking	100		
Filter frequency	2 20		
Minimum number of samples between detections	20		
Minimum value of the correlation coefficient	0.4		

As an output the application will indicate the portion of the continuous signal that correlates with the windowed template signal with a correlation coefficient higher than the threshold. A file is also produced that gives the time of these correlations. In the example below we see that the program is able to recover two close events in time that were not previously detected (see last figure).

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mber of samples in the template	512				
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fficient	0.4				
SAVE RUN Status FINI	SHED				
Name: VN.TDVBHHZ Sam	pling frequency: 100 [Hz] Sampl	es #: 360156 Max value: 2.16E+	+6 [NM/S] ↔ 🛨 🧲	1 🕂 🤁 🔁 🕒 Baseline c	orrection
-	00:12:57	00:02	00:33:07	00:43:12	00:53:16
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