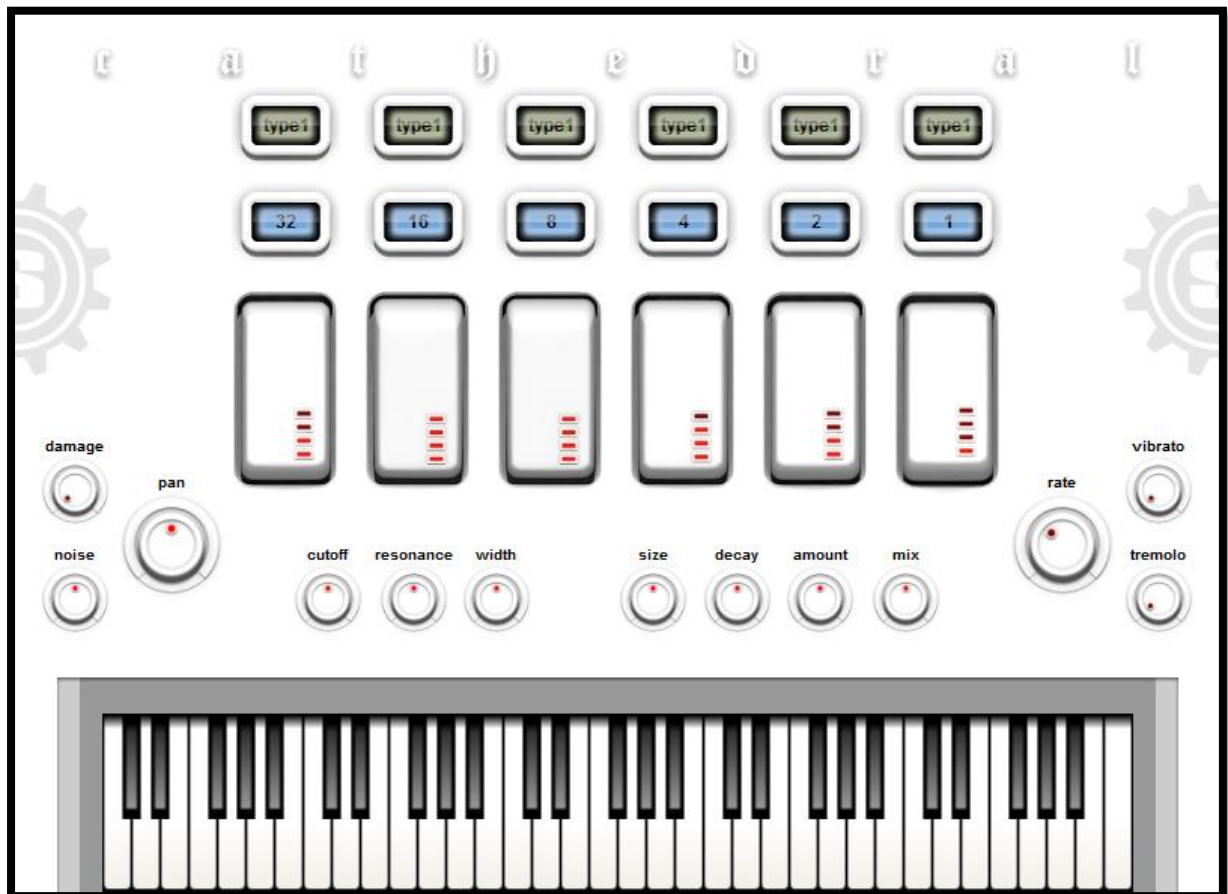




# Cathedral user guide & reference manual





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'Cathedral user guide and reference manual'

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## Introduction

Welcome to this user guide and reference manual for Cathedral. Over the next few pages you will read about the background of the Cathedral vst and discover how to use its features to create an array of pipe organ sounds.

## Inspiration

The inspiration for Cathedral comes from a search to try to find a convincing pipe organ sample set or VST instrument. Although there are many organ VST instruments available these are mainly focussed on tone-wheel organ emulation (drawbar organs such as the Hammond B3) or transistor organ emulation reminiscent of the electronic organs of the 1970s and early 1980s produced by manufacturers such as Crumar, Lowrey, Yamaha and Farfisa. The only pipe organ renditions that were available were sample based instruments that were large due to the sheer size of the sample sets used and also lacked flexibility because of limited polyphony. There was one notable exception in the sample based instruments; the Hauptwerk Virtual Pipe Organ. The Hauptwerk Virtual Pipe Organ offers enough polyphony and large sample libraries taken from real pipe organs and is therefore very flexible indeed and also provides an extremely realistic solution, however this still comes at a price as the sample libraries are still very large and the instrument is an expensive commercial product (when I started to develop Cathedral the sample playback engine of Hauptwerk could be freely downloaded and there were some free sample libraries available but it was under development as a commercial product).

The limited options prompted me to begin researching methods that could be used to create a virtual pipe organ that was flexible enough to recreate a large number of organ registrations, realistic in tone and playability and did not rely on large libraries of samples to create its sound. Two areas of research showed promise, physical modelling using a method based on commuted waveguide synthesis and analogue subtractive and additive synthesis.

## Additive Synthesis

An organ is effectively an additive synthesizer as the 16 or 8 foot pipes in a registration often represent a fundamental frequency with each subsequent pipe being either an odd or even harmonic of that fundamental frequency. Adding a stop to a registration adds in that harmonic and to an extent the level of the harmonic can also be controlled as most pipe organs will allow stops to be partially opened. While this is not as sophisticated as modern additive synthesis with only a few harmonics available it is still immensely flexible.



A simple approach would be to take a single sine wave oscillator at the fundamental frequency and then to add in further oscillators for each additional footage (or harmonic) to recreate the organ sound. This is essentially the most basic method for recreating an organ sound however the results are not very realistic.

## Wave Shaping

To enhance the realism of the simple system outlined above wave-shaping could be used using some form of modulation or using filters if the sine wave were replaced with something more harmonically complex such as a triangle wave or square wave. In addition to this the envelope applied could also significantly shape the sound to produce a more realistic result. The end result may still be limited and would not be completely realistic but is closer to the desired result. Indeed many commercial electronic church organs use this combination of subtractive and additive synthesis to create a fairly realistic and pleasing sound.

## Physical Modelling

Extremely realistic results for a single pipe can be produced using physical modelling by mathematically describing how air moves back and forth through a pipe and then converting this into a wave equation that can be reproduced in software. While physical modelling produces very realistic results it does present another problem; it is computationally expensive and therefore requires a lot of processing power, such that it may not be possible to reproduce the multiple pipes required for a full organ registration. Imagine for example that a single pipe used just 5% of CPU resources, that is not too bad, but what if a registration called for 5 different pipes, then you have used 25% of CPU resources and this is just to play 1 note. Now multiply your 5 pipe registration up by just 4 notes to play a chord and you have used up 100% of CPU resources and this is without allowing for an operating system or host application in the first place.

While physical modelling offers a good realistic result it is not entirely practical when it comes to CPU load. There is a solution to this problem however which is to take advantage of one aspect of physical modelling but to then couple this with a less expensive technique.

It is possible to model a single pipe as a resonating body and to then drive this resonator with not only the fundamental frequency but any additional harmonics, in other words a simple additive synthesizer could be used to drive a simple physical model to create a more realistic sound without such high CPU demand.



## The Cathedral VST Instrument

Cathedral is the product of the research discussed above plus a lot of in depth research into pipe organ registration and construction. It aims to provide a realistic reproduction of a pipe organ sound without relying on a vast library of samples and without unreasonably high CPU demand.

The sound is produced by using a simple virtual analogue additive synthesizer as an exciter for a virtual organ pipe model. To enhance the result further wave shaping is used for each of the oscillators in the exciter to allow for several different types of pipe to be recreated. Envelopes have been carefully created and scaled across the range of pipes and the keyboard range to create a realistic and natural response and all common pipe footages are available.

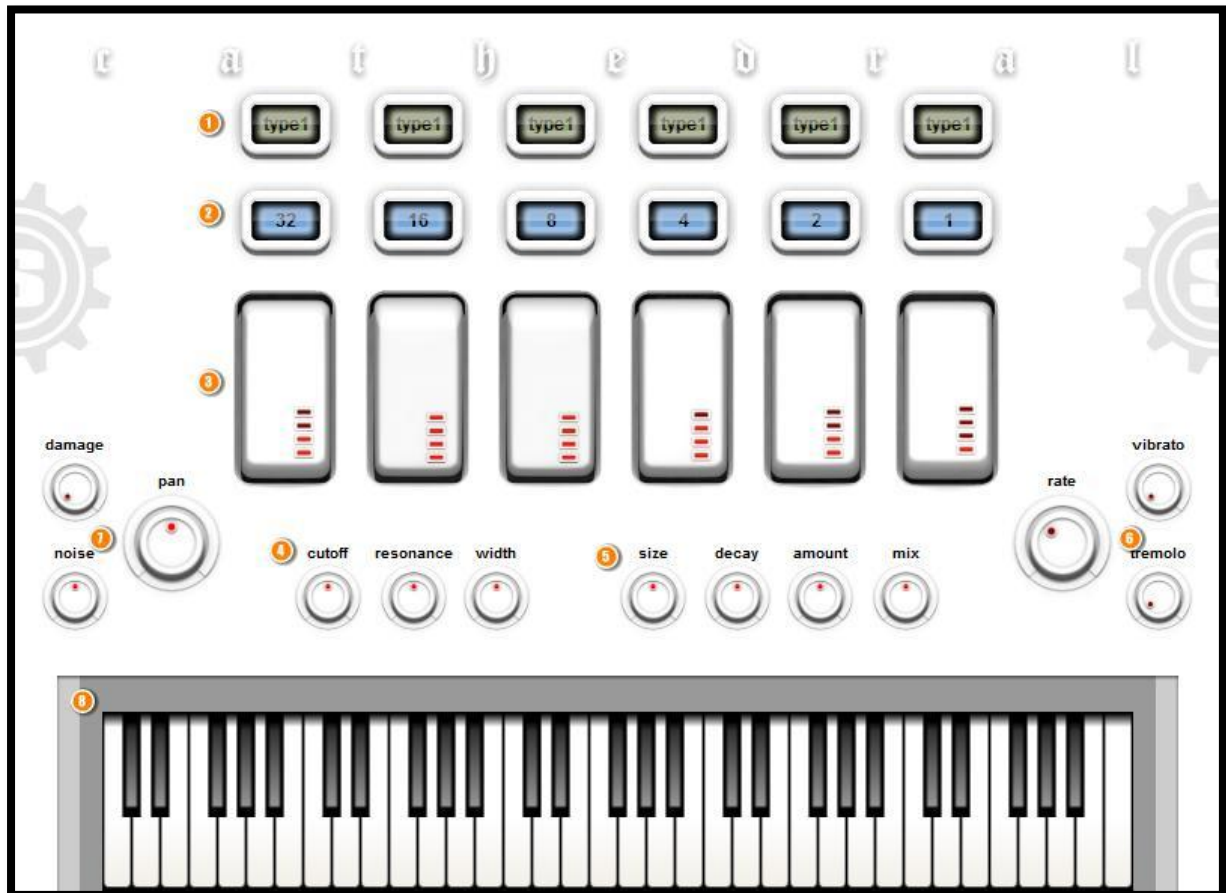
To provide a full sound while still offering the maximum flexibility, Cathedral provides up to 6 stops for each registration (up to 6 pipes); the stops themselves are not fixed but can be independently assigned to 1 of 3 different pipe types and 14 different footages and each stop has 5 different positions from fully closed (silent) to fully open (4 volume levels for each pipe). This means that any 1 stop can have 168 settings ( $3 * 4 * 14$ ) which in turn gives 22,483,074,023,424 possible combinations of all 6 stops sounding. While many of the differences would be subtle it is clearly a flexible instrument.

To enhance the sound further Cathedral includes an easy to use built in reverb. In truth it is as much the reverberation characteristics of the space an organ is placed in that make an organ's sound as it is the pipes themselves. A reverb is an essential component in such an instrument although there reverb here can be turned off completely and an external reverb can be used. Cathedral also includes a filter with adjustable bandwidth, cut-off and resonance to help further shape the sound; an LFO for tremolo effects (note that vibrato creates a rotary effect rather than a pitch vibrato) and an option to add noise and 'damage' to the instrument sound.



## Interface Overview

The interface uses a combination of icons, control knobs, switches and sliders to access the full range of parameters available. These are broken down into a number of sections as follows:



- 1 pipe type selection tabs - select 1 of 3 types (open flute, reed and closed flute), by clicking on the tab to cycle through the options;
- 2 footage selection tabs - select 1 of 14 footages (64, 32, 16,  $10\frac{2}{3}$ , 8,  $6\frac{2}{5}$ ,  $5\frac{1}{3}$ , 4,  $3\frac{1}{5}$ ,  $2\frac{2}{3}$ , 2,  $1\frac{3}{5}$ ,  $1\frac{1}{3}$  and 1), by clicking on the tab to cycle through the options;
- 3 organ stops - use the rocker switches to set the volume levels for each of the 6 organ stops by clicking and dragging up or down (lights indicate levels);



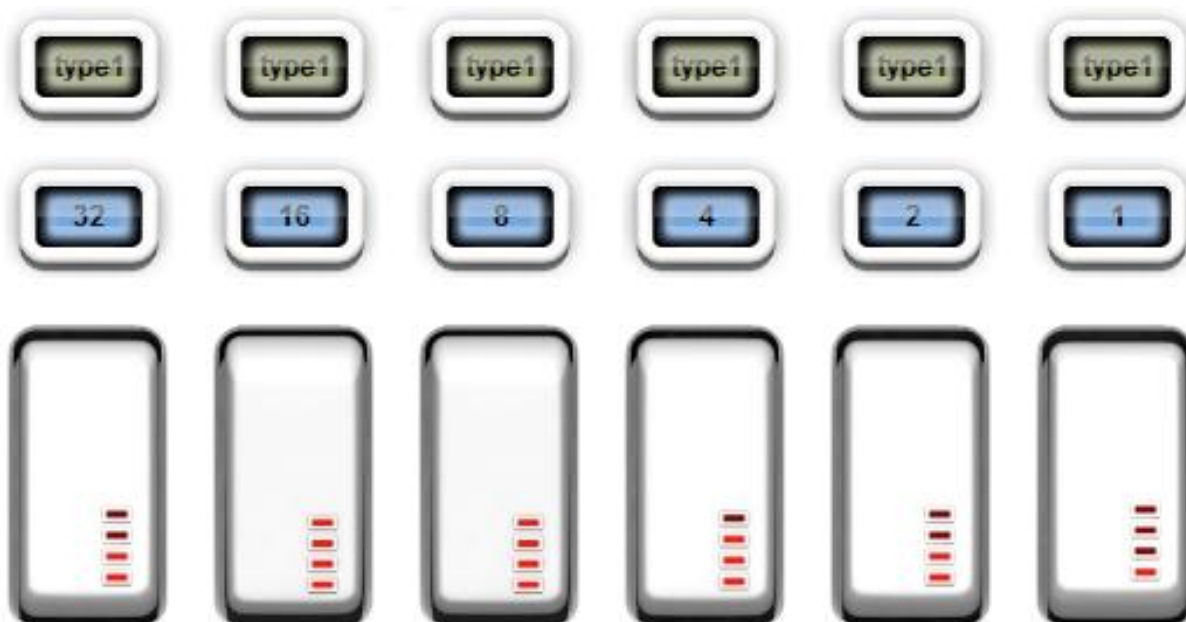
- 4 post-filter - the sound is filtered between the organ pipe model and the reverberation unit with control knobs for cut-off, resonance and bandwidth;
- 5 the reverberation unit offers control over the size of the reverberation space, the rate of decay, the amount of reverberation and the mix between the dry and wet signal;
- 6 the modulation section offers control over the rate of modulation, tremolo (simple amplitude modulation) and vibrato (in this case a rotary phasing effect);
- 7 some global controls are available for noise (the amount of apparent fan or bellows noise that leaks through the organ), damage (an additional modulation which radically alters the sound by phasing and chorusing) and panning;
- 8 the virtual keyboard can be played using a mouse and also shows which notes are being played; if a note gets stuck it may be freed by clicking on the corresponding key on the virtual keyboard.



## Sound Creation

Organ sounds are created by combining stops to add more or less pipes into the registration. In Cathedral this is done in the following stages:

- 1 select the type of pipe you want by clicking on the type tab (grey green in colour) until the type you want is selected (type1,2 or 3 correspond to open flute, reed and closed flute);
- 2 select the footage of pipe you want by clicking on the footage tab (blue in colour) until the correct footage is selected (clicking in the correct place on the tabs will give you a drop down list);
- 3 set the level for the stop by clicking and dragging the mouse over the respective rocker switch (from silence - 0 to full volume - 4);
- 4 repeat this process until you have added as many stops as you need;
- 5 remember to set the volume of any unwanted stops to 0.



*organ tabs and rockers*





## Presets

There are 16 presets included to give some idea of the possibilities available. These cover not only church organ but also include examples of theatre and fairground organ registration. The presets are as follows:

- 1** Big Church - a nice full sounding church organ in a large space;
- 2** Medium Church - lighter and brighter in a medium space;
- 3** Small Church - very simple organ with just 3 stops in a small space;
- 4** Fat 8ve Flutes - a full rich sound using only even harmonics;
- 5** Thirds and Fifths - a full rich sound using only odd harmonics;
- 6** Sweet and Simple Type 1 - 16 & 8 foot open flutes;
- 7** Sweet and Simple Type 2 - 16 & 8 foot reeds;
- 8** Sweet and Simple Type 3 - 16 & 8 foot closed flutes;
- 9** Big Pedal - very low frequencies - 64, 32 & 16 foot open flutes;
- 10** Coupled - 3 stops of type 1 pipe with 3 stops of type 2 an octave higher;
- 11** Wide Range - 32, 8 and 1 foot type 1 flutes for a light but wide sound;
- 12** Blackpool - a simple swirling theatre organ sound;
- 13** Amsterdam - fairground organ with fast modulation;
- 14** Distant Church - more reverberation than is absolutely necessary;
- 15** String & Choir Like - add a lot of damage and the sound is radically changed;
- 16** Initialized Patch - a nice classical organ sound.



## Limitations and Known Problems

Cathedral does have some limitations and known problems that users should be aware of, although there are workarounds to these as follows:

- 1** type 1 and type 3 sound the same - they are subtly different as are open and closed flutes on a real organ, however when filtering is applied this distinction can be lost so try increasing filter width and cut-off - some additional work may be done to improve this difference and also an additional pipe type or types may be added later;
- 2** I run out of notes when playing large chords - cathedral is 8 note polyphonic and should cope with most playing situations you could try using a different instance for each of the left hand, right hand and pedals;
- 3** The instrument cannot really recreate coupling between manuals - this is a real limitation however many hosts will allow you to send MIDI from one generator or instrument to another and this would be the same as coupling;
- 4** Some low frequencies are very quiet or buzz - this is just the nature of the instrument , however it is being looked into to see if it is possible to get a better balance for the lowest frequencies;
- 5** notes stick sometimes when switching between presets/patches - use the virtual keyboard to free up the stuck notes by clicking on any illuminated keys.

If you experience any problems with Cathedral please contact me via the following e-mail address and I will do my best to find a solution:

[saulc@saulc.karoo.co.uk](mailto:saulc@saulc.karoo.co.uk)