Keyboards made from rows of water jets, sprays, and nozzles as direct user-interfaces to water-based, fountain-based, and underwater musical instruments

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ABSTRACT

The "FUNtain" (hydraulophone) is an interactive multimedia fountain that responds when people block, one or more of the water jets, or touch, restrict, or interact with the jets. In particular, it can function as an extremely expressive musical instrument in which each jet of the fountain is a soft key that can be pressed in infinitely many ways to obtain fine control of note volume, pitch, and timbre. The closest counterpart to the hydraulophone, among previously existing instruments, is the pipe organ with true tracker-action.

With a tracker-organ, the attack and release are important expressive elements, but you can't really sustain partial wind supply to a pipe or it won't play at pitch: you can't keep a pipe partially speaking because you need full wind pressure. Hydraulophones, however, stay on-pitch at any amount of fluid flow, even when they are just beginning to speak. Therefore, with the hydraulophone, you can sustain notes at partial flow, for as long as you like. Most notably, you can attain polyphonic embouchure, with individual fine-control over expression of each element of a chord, by inserting and moving around each of your fingers in the mouths of the instrument in different ways. Unlike a flute player who obviously only has one mouth, typical hydraulophones are snake-like instruments that have 44, 61, or 88 mouths, each mouth providing a rich space of independently acting sound variations.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]; H.5.5 [**Sound and Music Computing**]; J.5 [**Computer Applications**]: ARTS AND HUMANITIES—*Fine arts*

General Terms

Design, Experimentation, Performance, Theory, Verification, Immersive

Keywords

Fluid-user-interface, direct user interface, water-based immersive multimedia, FUNtain, hydraulophone

1. INTRODUCTION

Hydraulics is the branch of engineering and science pertaining to mechanical properties of liquids, and fluid power. The word "hydraulics" comes from the Greek word for "water organ", a musical device consisting of hydraulically blown wind pipes used to imitate the chirps ("songs") of birds [http://wikipedia.org/wiki/Water_organ]. The Hydraulis was also a water-powered but air-based pipe organ, in which water power was used to blow air into organ pipes.

Both the Greek "water-organ" as well as the Hydraulis were water-powered wind (air) instruments, the difference being that the "water-organ" worked like a player piano (i.e. played itself), whereas the Hydraulis was a keyboard instrument (the world's first keyboard instrument), played by pressing down on wooden keys or levers. [http://wikipedia.org/wiki/Hydraulis].

2. THE HYDRAULOPHONE: A TRULY HYDRAULIC MUSICAL INSTRUMENT

In this paper we explore the use of water for both the production of sound, as well as for use as a direct (and tangible) user-interface. This research derives its inspiration from the screeching sounds made by defective faucets, and other valves with liquids passing through them, giving rise to the discovery and exploration of various water-based multimedia devices such as musical instruments [**?**]. In particular, various underwater musical instruments were made from simple devices (some hand-cranked or pumped like an acordian, others motorized) that rapidly turned water jets on and off, or forced water through resonant orifices, and, additionally, other water-based musical instruments and interfaces such as organ pipes with water actually flowing through the pipe and fipple mechanism, were explored. [**?**] These new interfaces were a big hit with children at public pools. The introduction of water as a new multimedia interactive design element, and water-sprays as user-interfaces, created a new form of tangible media [**?**][**?**][**?**][**?**] that people as young as six months old could immediately relate to.

2.1 Music without air

Children enjoyed going under water and listening to and playing these instruments, at the public wading pools and community "fun swims" where the water-based instruments were set up. When a person is under water, there can be water touching the outside of the eardrum, so that sound may be conveyed from the underwater musical instrument to the eardrum, without requiring the sound to travel through air.

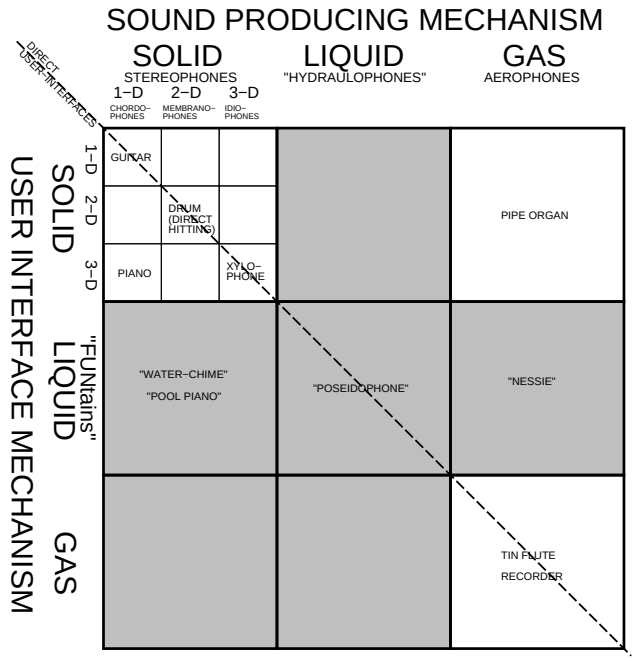

Figure 1: Categorization of musical instruments by both their input (user-interface) and output (sound-producing mechanism) suggests the possibility of some new instruments within the shaded regions.

Moreover, the way that human hearing works, sound continues from the eardrum, through solid matter (the auditory ossicles, which are the three smallest bones in the human body), to liquid-filled cochlea of the inner ear, completing the hearing path all the way from the musical instrument to our perception, without ever involving air.

2.2 Hydraulophone as a new category of musical instrument

Traditionally musical instruments are broadly classified, by their scientific names, as either wind instruments (aerophones, from the Greek words "phonos" = sounding, and "aero" = wind), or solid instruments (self-sounding instruments in which solid matter vibrates to then cause the surrounding air to vibrate). Solid instruments are further subdivided into idiophones (three-dimensional solids, e.g. xylophones), membranophones (two-dimensional solids, e.g. drum membranes) and chordophones (one-dimensional solids, e.g. stringed instruments like pianos and guitars). The water-based instrument suggests a new category of instrument, in which liquid is the sounding mechanism, rather than solid or gas (See Fig. 1).

2.3 Wet/dry and amphibious hydraulophones

Hydraulophones may further be broken down into three categories:

1. Water-in-air: instruments in which the sound-producing mechanism is water, but where the instrument is ordinarily played above the surface of the water;
2. Air-in-water: underwater instruments which involve air in some way, or at least mixtures of air and water;
3. Water-in-water: underwater instruments in which the sound-producing mechanism is water. No air is required, or involved, in the production of the sound.

The amphibious hydraulophone may also be played in a very expressive way, by moving it in and out of the water. Like a traditional air-based woodwind (such as a flute) in which embouchure is used to control the expression, the hydraulophone also has expression based on embouchure, except that you control the expression by moving the mouth of the instrument in and out of the water, etc., rather than with your own mouth.

2.4 Wet/dry user-interfaces: Achieving a Direct User Interface by using water as both the sound-producing mechanism, as well as the user-interface

The traditional scientific classification of musical instruments is based on how they output (make) sound, but if we go to a music store to purchase a musical instrument, we will find that they are usually categorized by input (user-interface). Thus the keyboard instruments, like pianos, accordions, organs, and synthesizers, will all be together, perhaps on the main floor. Upstairs you might find the instruments that you blow into (flutes, woodwinds, brass), and downstairs you might find all the instruments that you play by hitting them (drums, xylophones, etc.).

Classification based on both input (user-interface) and output (sounding mechanism) suggests a possible new space of water-based instruments that includes also the use of liquid as a user-interface.

3. FUNTAIN DESIGN: NESSIE THE SEA MONSTER

Recently, we designed and built a sculptural housing for the FUNtain/hydraulophone, having the shape of a cute sea serpent, that we call "Nessie", whymsically named after the sea monster said to inhabit Scotland's Loch Ness.

Nessie's user-interface consists of 12 jets, plus her mouth, and her entire body. Embouchure is controlled by the position of Nessie's mouth in the water (rather than by the user's own mouth as in a traditional flute), to obtain a very expressive and diverse array of sounds over a two-and-a-half octave range.

The Loch Ness Monster features in a number of children's stories, such as "The Loch Ness Monster" by Margo Fallis, http://www.electricscotland.com/kids/stories/lochness_monster.htm and with its long and slender shape, makes a good basis of inspiration for a series of tubular waterpipe-organ/waterflute sculptures.

Children all around Toronto are now familiar with Nessie, the cute green serpent-shaped hydraulophone, shown in Fig.2.

Nessie has made daily appearances at various of the wading pools throughout the city, turning these wading pools into multimedia play areas. There is a regular Nessie following among many Torontonians who come to see the next "Nessie sighting".

Many of the children would run over to give Nessie a big hug, and some would cry when Nessie had to go home at the end of the day. Nessie was also very popular among the elderly, and she visited a number of retirement homes to combine music therapy with water therapy. Because the water-based user-interface is very soothing, those suffering from arthritis, and unable to play other instruments, find the instrument very easy to play. Because of the tactile nature of water streams, the water-based user-interface has also been worked well for special needs children as well as the blind and visually impaired (partially sighted).

We are presently installing a number of hydraulophones in public spaces such as parks and recreation areas. If you

Figure 2: **"Nessie the fun poseidophone":** Nessie sighting in "loch Grange" (Grange Park wading pool). Neighbourhood children converge on Nessie. Later Nessie sighting at Eden Manor retirement home in Toronto.

would like a quotation to have a hydraulophone installed in your park, pool, or as a beautiful sculpture outside of your building, please contact us to arrange for a demonstration. See http://funtain.ca

4. CONCLUSIONS AND SUMMARY

Hydro-acoustic fluid user-interfaces were explored. In particular, it was found that an array of water jets formed a new and useful input device that functioned like a "soft" and expressive keyboard.

5. ACKNOWLEDGEMENTS

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