A Review of Mechatronic Chordophone Pickers & Dampers

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1 Overview

The field of mechatronic instruments aims to expand upon the human experiences of composing and performing music. Mechatronic instruments have the ability assist and enhance music playing, as well as producing new types of music that a human would find difficult or not be capable of replicating [1]. The mechatronic chordophone provides a fast and precise method of producing music with stringed instruments [2]. Below in Figure 1, the base components of a mechatronic chordophone are outlined. This review we will outline different picking and damping mechanisms, and will look to identify their advantages and limitations.

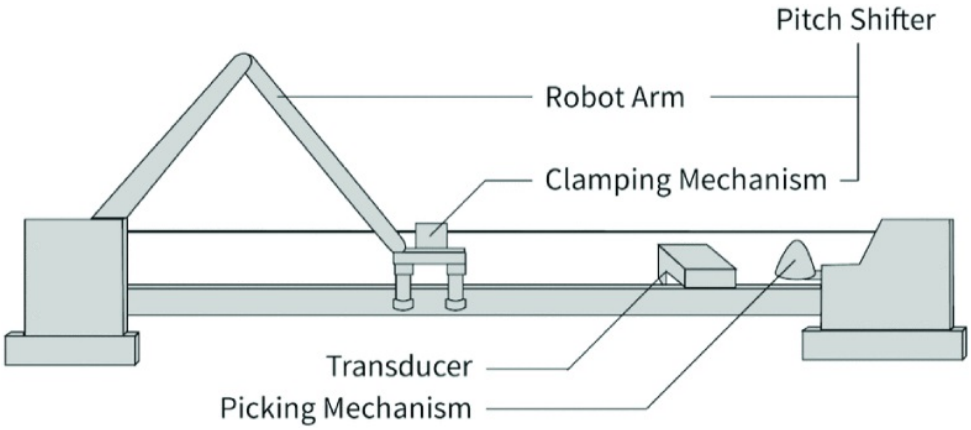

Figure 1: Overview of common mechatronic chordophone construction [2]

2 Review of Literature

2.1 Mechatronic Picking Mechanisms

Most common mechatronic picking mechanisms can be categorised by the actuators they use for picking. Solenoids actuator designs provide a linear motion, moving the pick back and forth over the string. Stepper motors have a rotary motion with large numbers of picks located in a central hub.

2.1.1 Solenoid Actuated Picking Mechanisms

Solenoid actuator based picking mechanisms present a very simple to implement and cost effective design, as solenoids are inexpensive and do not require any driving circuitry other than a simple MOSFET [3]. Existing picking designs such as the Poly-tangent Automatic (multi-)Monochord (PAM) [4] are based on using two solenoid actuators in a push-pull configuration, moving the pick back and forth across the string. This picking system was recreated at Wellington University Victoria, and demonstrated a picking speed of 20 nps (notes per second).
Due to the back and forth motion of the pick using this method, it has been suggested that this design allows for a more accurate recreation of actual human strumming [5]. However it has

also be demonstrated that small differences in the two solenoids will lead to very large acoustic differences between the backwards and forwards stroke of the pick [3]. It has also been said that the back and forth motion of this pick will constrain the picking angle to being vertical, as any other picking angle will have drastically different forward and backward interactions [6].

2.1.2 Stepper Motor Actuated Picking Mechanisms

Stepper motor actuated picking mechanisms tend to come in the form of a 'pick-wheel', with multiple picks mounted to a single motor. The design allows for varying pick attack angles, as well as varying the numbers of picks per full rotation of the motor [2, 6]. According to these sources, a stepper motor based picker is capable of achieving picking speeds of 25 nps.
A well developed example of this style of picking mechanism can be found in the 'MechBase' [7], using a pick-wheel with five picks attached. The picking mechanism from 'MechBase' allows for adjustment of loudness and timbre by adjusting the position of the pick-wheel with a servo driven pivot [6]. This allows the 'MechBase' to produce a wider range of picking effects, and more accurately recreate human playing.
This style of actuator has also had a mechanism designed that allows for dynamic adjustment of the picking angle, using a second stepper motor and a worm gear to hold each of the picks [6]. However, This method of adjusting the pick angle doubles the electromagnetic noised generated by the motors, and currently does not allow for changes of the mounting height to adjust loudness and timbre.

2.1.3 Novel Picking Mechanisms

There also exist a selection of more novel picking mechanisms the allow for the generation of an array of different sounds. One such mechanism is the Robotically Augmented Electric Guitar [1], which uses an array of actuatable hammers. This design looks to enhance the playing of the instrument by adding fast rhythmic patterns alongside normal playing. Another novel actuation and picking method is presented by Steven Kemper, in which DC vibration motors are used quickly agitate the string, producing a mechatronic 'tremolo' effect [8].

2.2 Mechatronic Damping Mechanisms

The ability stop or decrease the vibration of an instruments strings allows for the articulation of specific notes, and is a pivotal components of a mechatronic chordophone [2]. The literature reviewed presented two different mechanisms to actuate this damping, either using a solenoid such as in the LEMUR 'GuitarBot' [9], or a servo motor such as in the 'MechBase' [7]. Both of these damping mechanisms work on the same basic principle, and remove energy from the vibrating string by contacting it with a foam, soft plastic or polymer. Servo based damping mechanisms have an advantage in that they are able to dynamically adjust the damping by varying the force applied to to string [6].

3 Discussion

Overall, there can be no one best mechanism, with each providing a unique sound that may serve a purpose. In regards to picking mechanisms, it is clear that there is a wide variety of different mechanisms and actuator types that are able to produce an extensive array of sounds. In the literature, stepper motor based designs have so far provided the greatest flexibility, however there is still clear room for improvement an all researched designs. In regard to damping mechanisms, there is a clear gap in development, with the possibility of more adaptive and robust designs.

References

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