A Soft-Robotic Auto-Tuner for String Instruments

**Abstract**

This project presents the design and prototyping of a universal robotic tuning device capable of automatically adjusting the pitch of various string instruments. By integrating a soft robotic gripper, a flexible transmission mechanism, and a pitch detection module based on microphone input, the system can adapt to different tuning pegs and provide real-time automatic tuning.

**1. Introduction**

Manual tuning of string instruments is time-consuming and requires experience, especially when dealing with multiple instruments. There is a growing demand for affordable, intelligent, and adaptable tuning systems that can support both beginners and professionals. This project aims to develop a low-cost, portable robotic system to automate the tuning process across a variety of string instruments.

**2. Related Work / Literature Review**

Previous solutions such as Roadie 3 focus primarily on guitar tuning and rely on rigid, fixed-size attachments. Recent developments in soft robotics and flexible actuators open new possibilities for adaptive systems.

Key references:

* Zhang et al.,“Reinforcement Learning-based Adaptive Tuning,” IEEE IM, 2022
* Kim et al., “Soft Robotic Gripper for Delicate Manipulation,” Soft Robotics Journal,2021
* Band Industries: Roadie 3 Auto Tuner ([https://www.roadiemusic.com](https://www.roadiemusic.com/))

**3. System Design**

**3.1 Hardware Components**

* Arduino UNO microcontroller
* MAX9814 microphone amplifier module
* SG90 servo motor
* Soft robotic gripper （custom design）
* Flexible drill-shaft-like transmission
* Power supply and breadboard wiring

**3.2 Pitch Detection**

Using the MAX9814 module, analog sound signals are captured and analyzed in Arduino through a zero-crossing algorithm to estimate frequency.

**3.3 Actuation Mechanism**

The motor torque is transferred through a flexible shaft （like a drill converter） to the soft robotic gripper. The gripper adapts to the tuning peg shape and rotates it gently.

**3.4 Control Logic**

The system detects current pitch, compares it with the target frequency automatically, and rotates the servo accordingly to increase or decrease tension until the correct pitch is reached.

**4. Implementation**

* Arduino reads analog signal from A0 （MAX9814 OUT）
* Frequency is estimated every 50ms using zero-crossing detection
* Servo adjusts angle in small steps until pitch is correct
* Serial monitor outputs current frequency and deviation

**5. Results and Testing**

* Piezo sensor detection failed due to the low sensitivity
* Testing microphone (MAX9814)

**6. Challenges and Future Work**

* Testing micrphone sensor fot detecting pitch
* Expand to multi-string simultaneous tuning
* Desgin the soft gripper
* Combine the motor with the soft gripper

**7. Conclusion**

The proposed system demonstrates a novel combination of soft robotics and pitch detection to create an adaptive tuning tool. Its universal applicability, low cost, and expandability make it a strong candidate for further development.

**8. References**

1. Zhang, H. et al. （2022）. Reinforcement Learning-Based Adaptive Tuning. IEEE Instrumentation Magazine.
2. Kim, Y. et al. （2021）. Soft Gripper Design for Delicate Manipulation. Soft Robotics Journal.
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4. Chu, L. et al. （2020）. Sensor-Based Auto Tuning Device. Sensors and Actuators A.
5. Yang, M. et al. （2019）. Low-power Real-time Pitch Detection. Journal of Signal Processing Systems.