Optimizing Labor Progress with Advanced Cervical Dilation Measuring Device

CerviArc

TEAM-5

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Problem Statement?

Develop a device that can accurately and objectively measure cervical dilation, to standardize labour assessment and enhance the safety and effectiveness of childbirth management.

Current method of assessing cervical dilation?

Digital vaginal examination

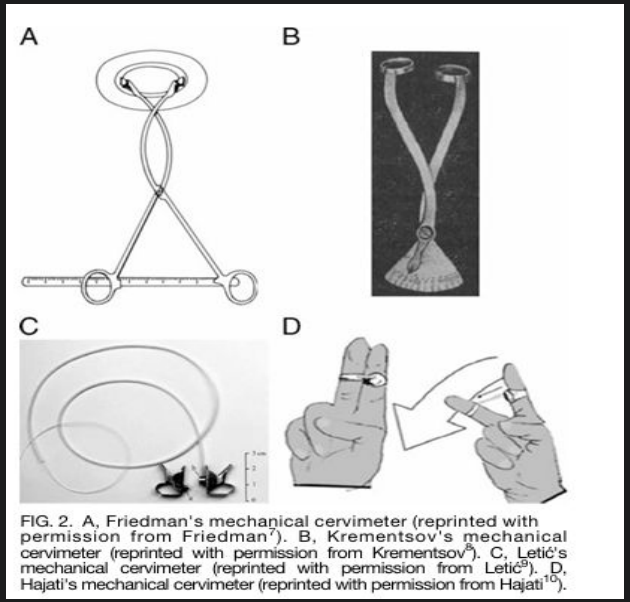

FIG. 2. A, Friedman's mechanical cervimeter (reprinted with permission from Friedman[7]). B, Krementsov's mechanical cervimeter (reprinted with permission from Krementsov[8]). C, Letić's mechanical cervimeter (reprinted with permission from Letić[9]). D, Hajati's mechanical cervimeter (reprinted with permission from Hajati[10]).

Devices for Measuring Cervical Dilation During Labor: Systematic Review and Meta-analysis

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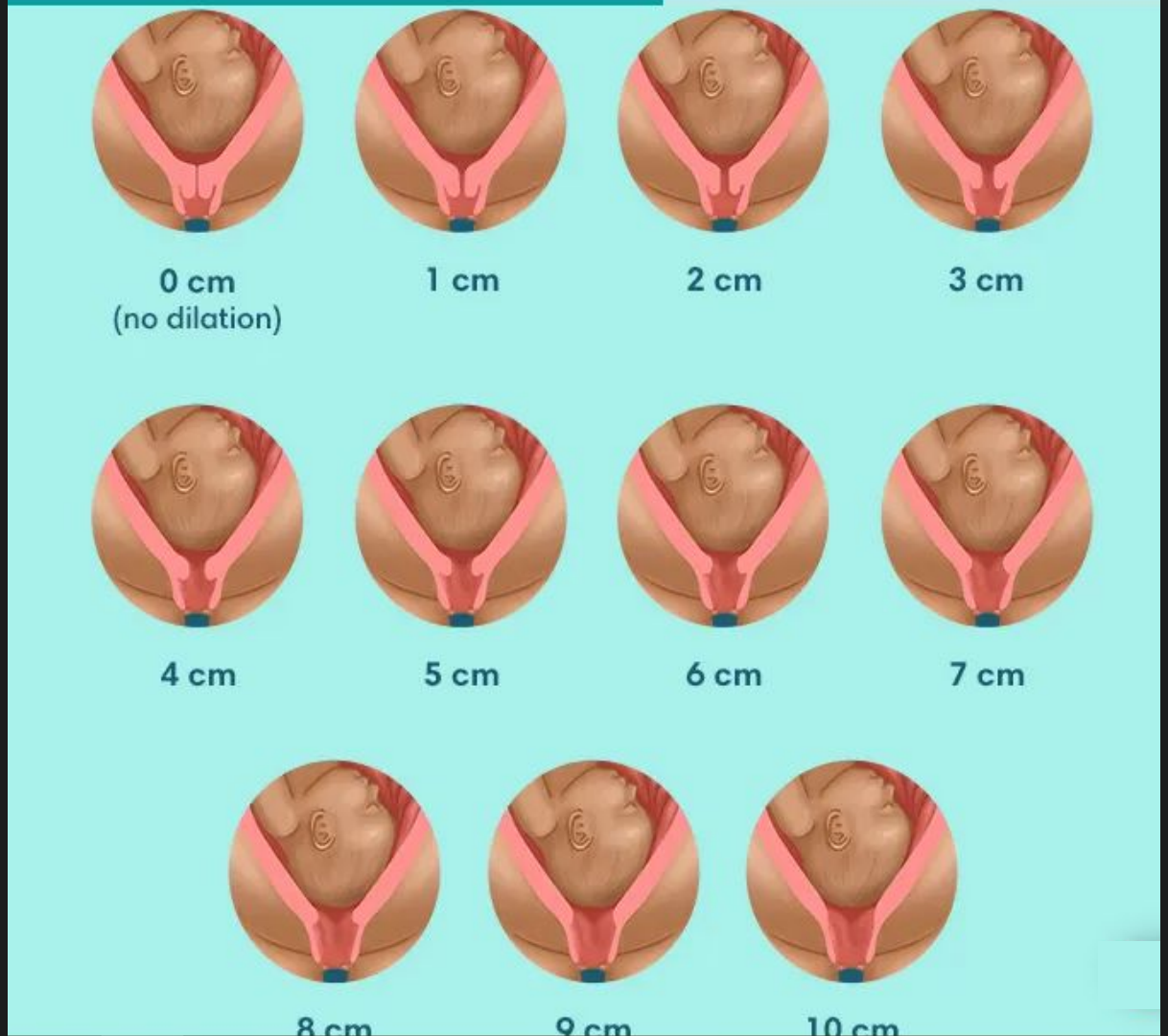
Why CerviArc?

- **Patient-Centric**: Constructed from flexible, biocompatible materials for safe and comfortable use during labor.
- **Innovative Design:** Utilizes a mini inverted umbrella mechanism for gradual expansion and measurement.
- **Real-Time Data:** Equipped with conductive sensors that provide immediate feedback on dilation status.
- **Enhanced Decision-Making:** Offers objective data to aid healthcare professionals in making informed clinical decisions.

DILATION

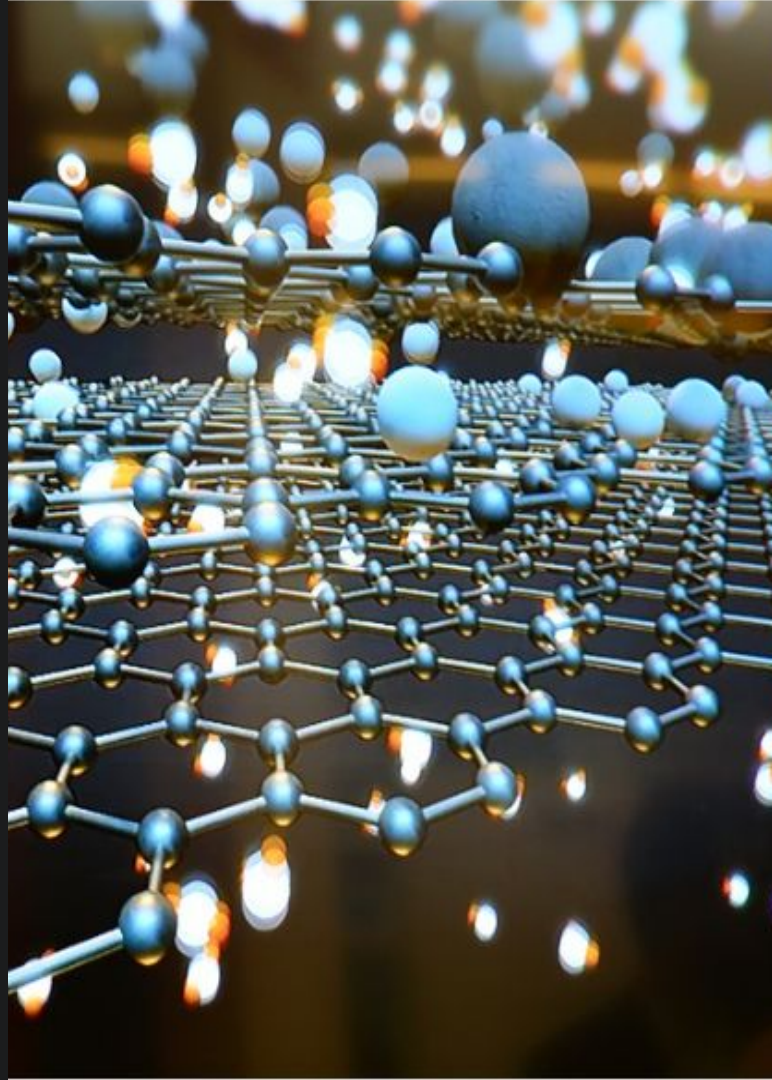


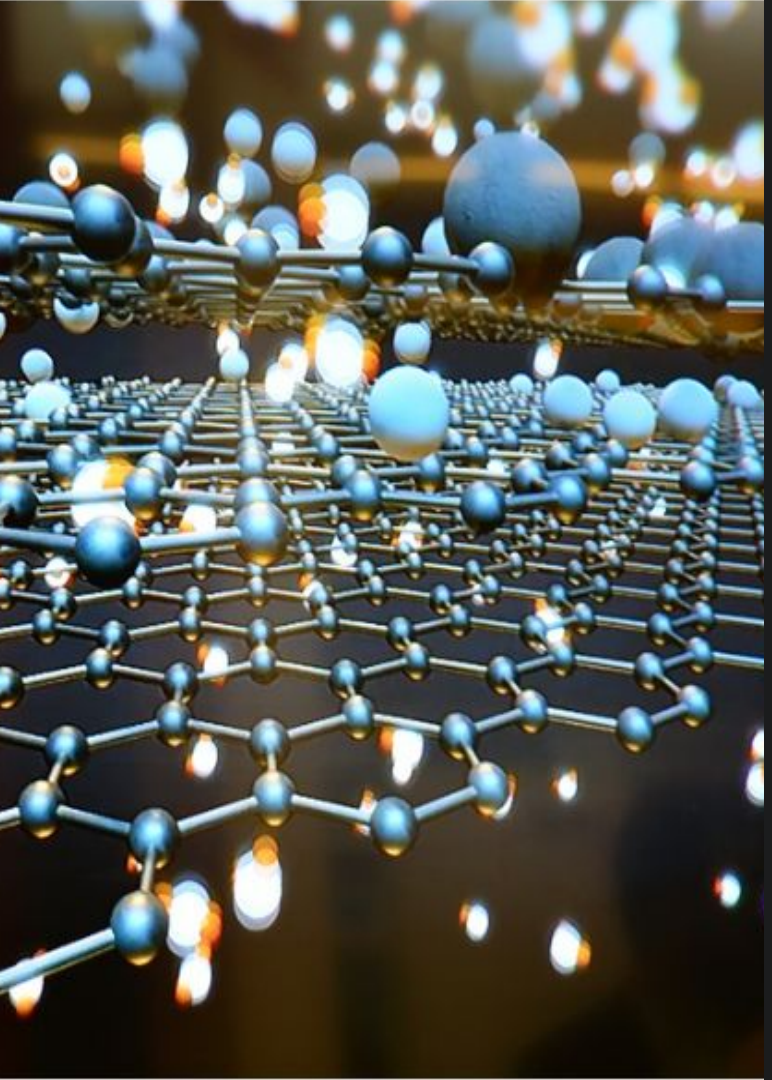
MEASUREMENT

Materials Used?

1. Thinner Hollow Cylinder

LAYERS	PURPOSE	PROPERTY
OUTER: **Medical-Grade Silicone**	superior comfort and flexibility	**Soft, Pliable,** Highly biocompatible & Excellent resistance
MIDDLE: **Polyurethane (PU)**	added support and durability while maintaining flexibility and comfort.	Good tensile strength, strong enough to resist deformation when the mini umbrella expands.
INNER: **Polyether Ether Ketone (PEEK) or UHMWPE**	structural backbone, providing resistance to internal pressure	mechanical strength, wear resistance, biocompatibility, High strength-to-weight ratio, low friction, and very durable.





2. Mini Umbrella Membrane

Medical-Grade Silicone

- Non-Conductive
- Biocompatible
- Flexible & Foldable
- Durable
- Elasticity

A Novel Cervical Wall Pressure Sensor

This presentation introduces an innovative cervical wall pressure sensor that utilizes a quartz crystal embedded within a deformable, biocompatible sphere. This novel design allows for continuous monitoring of pressure exerted by the cervical wall during dilation procedures.

The Concept: Quartz Crystal within a Deformable Sphere

Deformable Sphere

The sensor is encased in a hollow, biocompatible sphere that can deform under pressure from the cervical wall.

Quartz Crystal

A quartz crystal is embedded within the sphere, which generates an electrical signal when compressed due to the piezoelectric effect.

Pressure Sensing

The deformation of the sphere and subsequent compression of the quartz crystal allows the sensor to measure the pressure exerted by the cervical wall.

Sensor Design and Diagram

Sensor Components

The sensor consists of a hollow, deformable sphere made of a biocompatible material, with a quartz crystal at its core.

Electrical Connections

Electrical leads connect the quartz crystal to an external signal processing and data acquisition system.

Overall Design

The compact, spherical design allows for easy insertion and placement within the cervical canal during dilation procedures.

Working Principle: Pressure Deformation and Signal Transduction

1

Pressure Deformation

When the cervical wall exerts pressure on the sensor, the deformable sphere deforms, compressing the embedded quartz crystal.

2

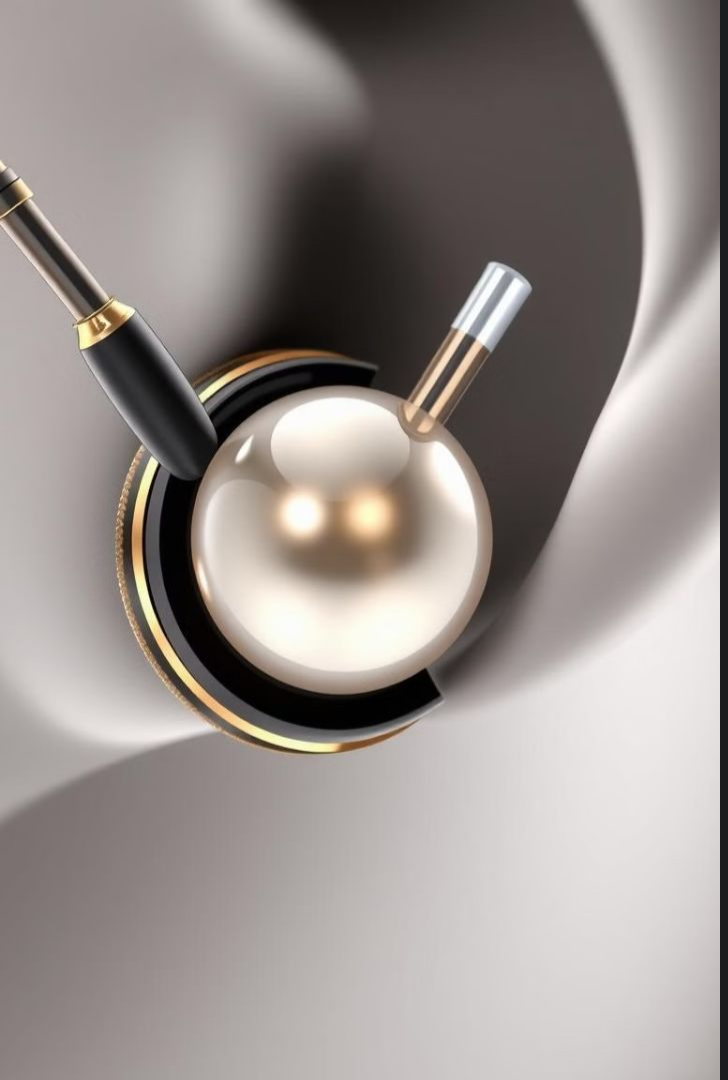
Piezoelectric Effect

The compression of the quartz crystal generates an electrical signal due to the piezoelectric effect, which can be measured and analyzed.

3

Signal Transduction

The electrical signal produced by the quartz crystal is transmitted through the electrical leads to an external data acquisition system for further processing.



Advantages of the Sensor

1 **Accurate Pressure Monitoring**

The sensor's design allows for precise and continuous measurement of cervical wall pressure during dilation procedures.

2 **Biocompatibility**

The use of a biocompatible material for the deformable sphere ensures patient safety and comfort.

3 **Compact and Portable**

The small, spherical design of the sensor enables easy insertion and positioning within the cervical canal.

4 **Real-Time Data**

The sensor provides immediate feedback on cervical wall pressure, allowing for more informed decision-making during procedures.

Current State of the Technology

1

Prototype Development

The cervical wall pressure sensor is currently in the prototype development stage, undergoing rigorous testing and refinement.

2

Clinical Trials

Once the prototype is finalized, the sensor will undergo clinical trials to evaluate its performance and safety in real-world medical settings.

3

Regulatory Approval

After successful clinical trials, the sensor will seek regulatory approval for commercial use in medical procedures.

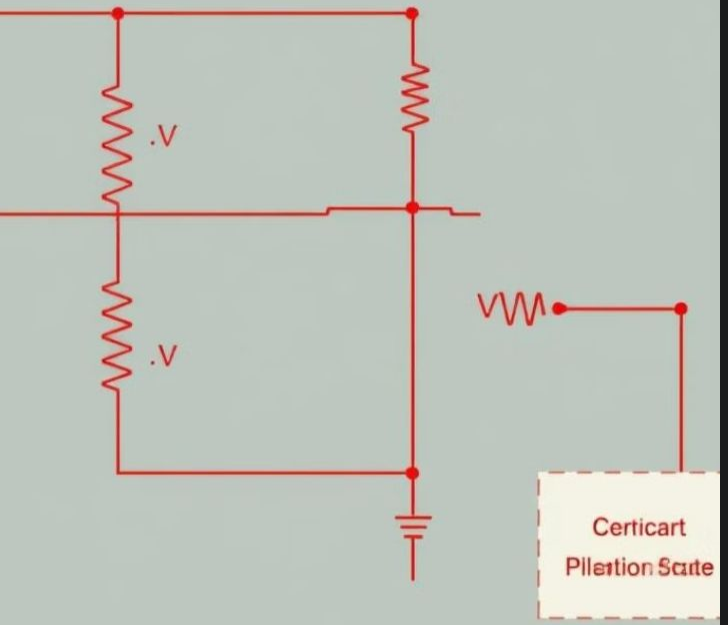
Future Directions

The cervical wall pressure sensor represents a significant advancement in the field of medical instrumentation. Its innovative design and precise pressure monitoring capabilities have the potential to revolutionize cervical dilation procedures, providing healthcare professionals with critical real-time data to improve patient outcomes.

Future research directions may include further miniaturization of the sensor, integration with other medical devices, and exploration of additional applications beyond cervical dilation monitoring.

Future Enhancements

The future advancements also includes the inducing of the CERVIARC into the uterus so that the cervix walls are being expanded for pregnant women who whose dilation is very slow.
Also, introduction of image processing will be a major development in the field of gynaecology since we can predict the delivery of the baby and hence obtain a safe environment for both parent and the child



Instrumentation and Filtering

1

Signal Amplification

An instrumentation amplifier boosts the small sensor signals to measurable levels.

2

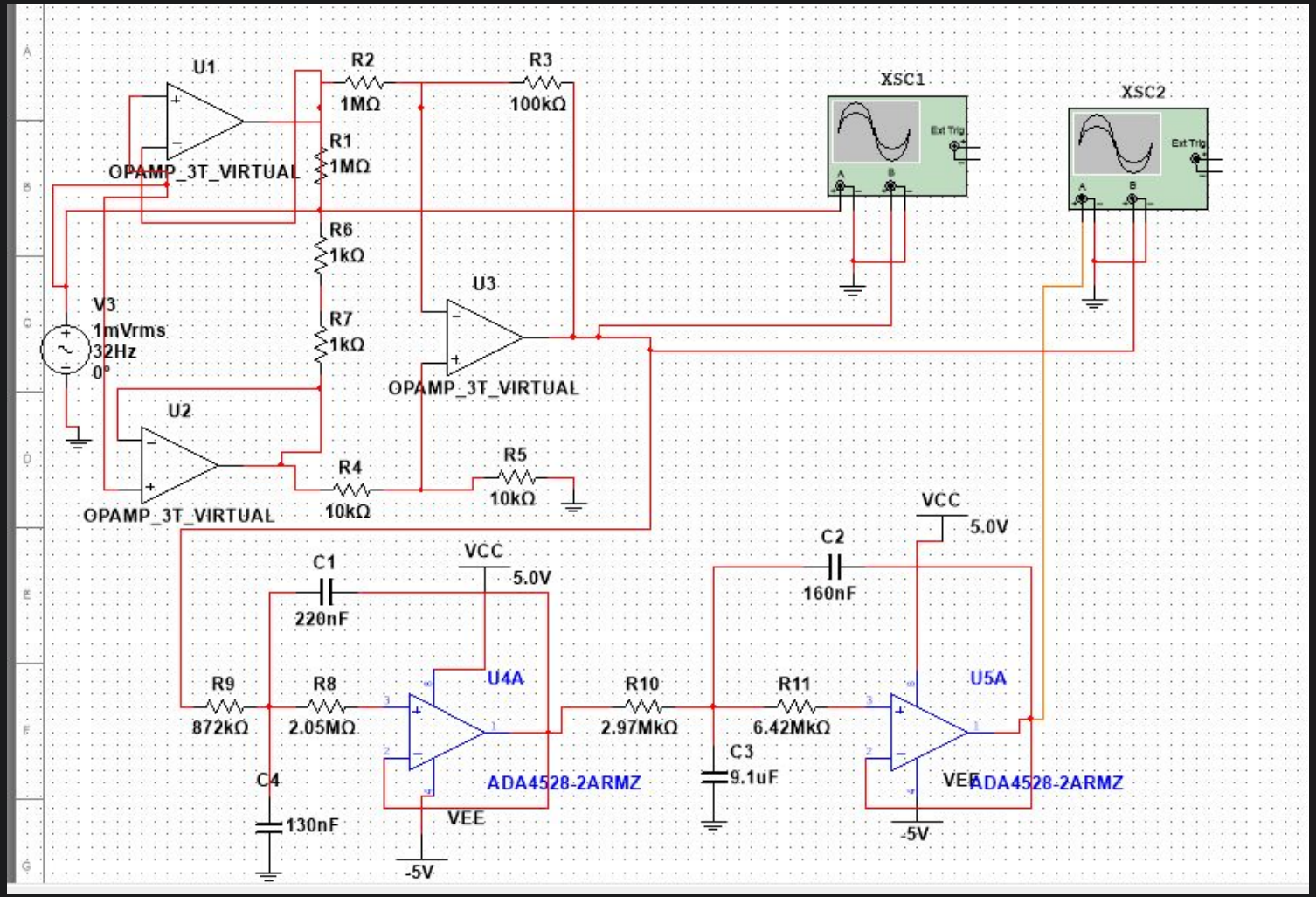
Noise Reduction

Filtering circuits remove unwanted electrical noise and interference from the sensor data.

3

Digital Conversion

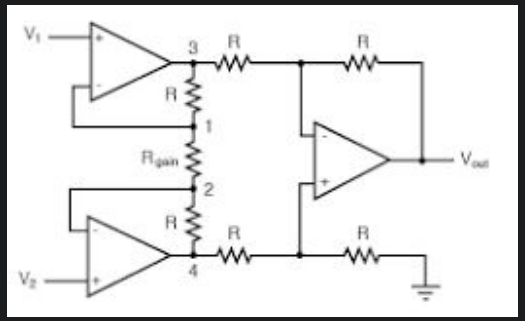
Analog-to-digital conversion allows the sensor data to be processed by a microcontroller.


U1
R2
1MΩ
R3
100kΩ
XSC1
XSC2
Ext Trig
A
B
OPAMP_3T_VIRTUAL
R1
1MΩ
R6
1kΩ
U3
V3
1mVrms
32Hz
0°
R7
1kΩ
OPAMP_3T_VIRTUAL
U2
R4
10kΩ
R5
10kΩ
OPAMP_3T_VIRTUAL
VCC
5.0V
C1
220nF
C2
160nF
R9
872kΩ
R8
2.05MΩ
U4A
R10
2.97MkΩ
R11
6.42MkΩ
U5A
C4
130nF
ADA4528-2ARMZ
C3
9.1uF
VEE
-5V
ADA4528-2ARMZ

Instrumentation and Filtering

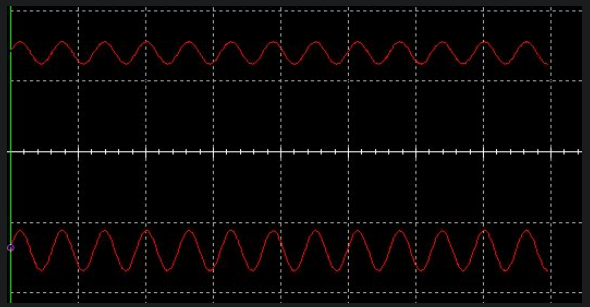
Purpose: Boosts weak signals from the strain gauges for accurate processing.

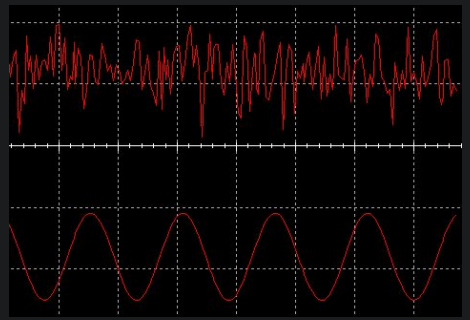
Instrumentation Amplifier: Used to amplify the small voltage changes caused by the deformation of the quartz material.



- **Key Feature**: High input impedance and low noise.
- **Component**: **INA126** or **INA128** (Precision instrumentation amplifiers).

Importance: Amplifying low-level signals ensures that even minor changes in cervical dilation are detected.





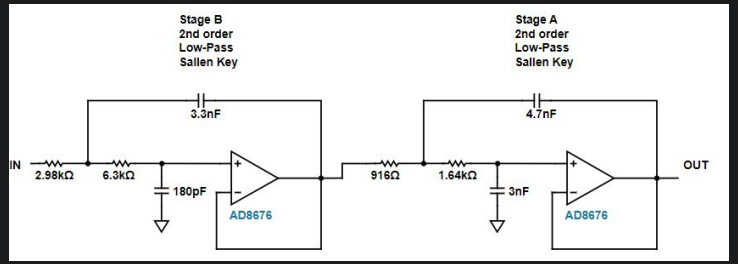
Chebyshev 4th Order Filter

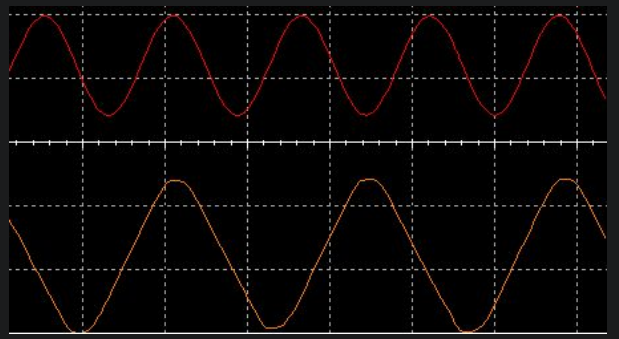
Purpose: Reduces noise in the sensor signal for precise measurement.

Filter Type: Chebyshev 4th Order – Chosen for its steep roll-off characteristics, ensuring minimal interference while preserving signal integrity.

Function: Removes high-frequency noise caused by electrical interference.

Outcome: Provides a cleaner signal, allowing accurate real-time dilation measurements.





Materials and Fabrication

Biocompatible

Materials must be safe for medical use and skin contact.

Sterilizable

Components need to withstand sterilization processes.

Miniaturized

Compact design allows for easy integration into medical devices.

Durable

Materials and construction must be resistant to wear and tear.

AI/ML-based Approach

1

Real time Data

Collect real-time measurements of cervical dilation.

2

Machine Learning

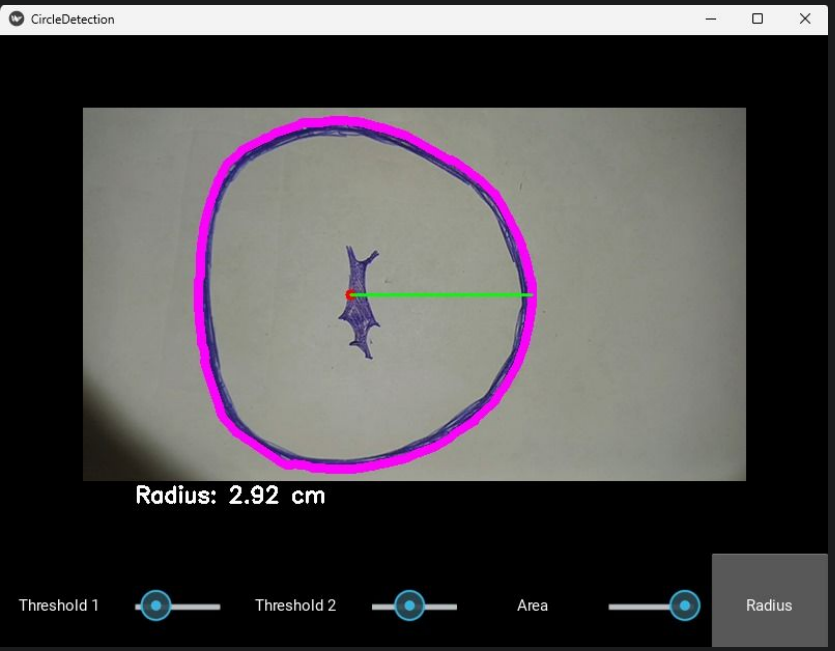
Apply advanced AI algorithms to analyze sensor data patterns.

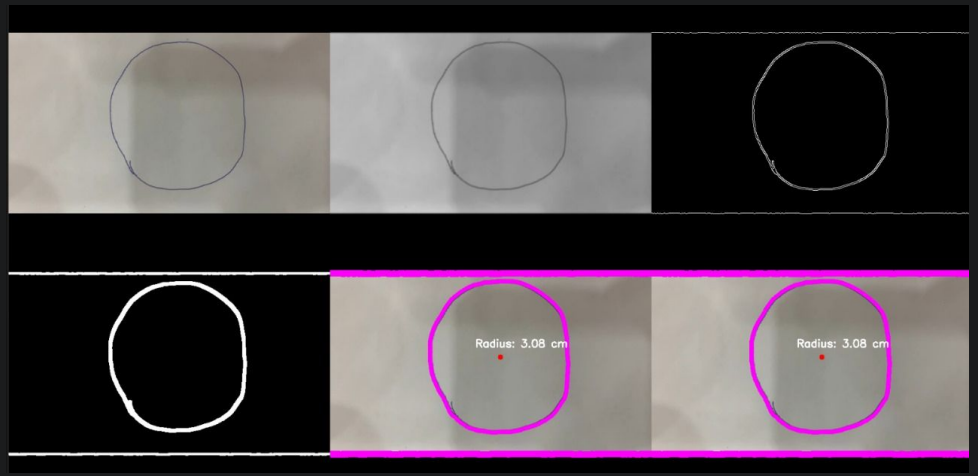
3

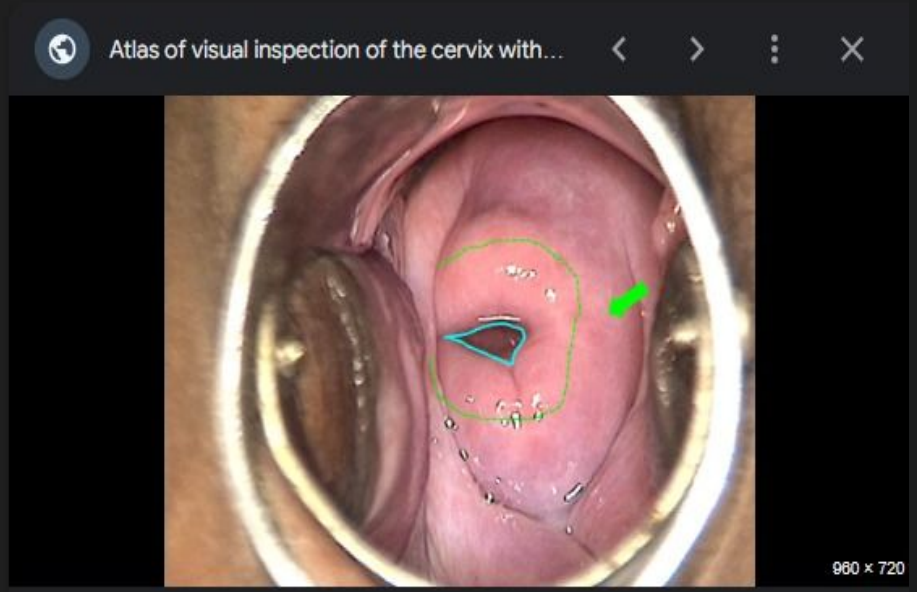
Predictive Modeling

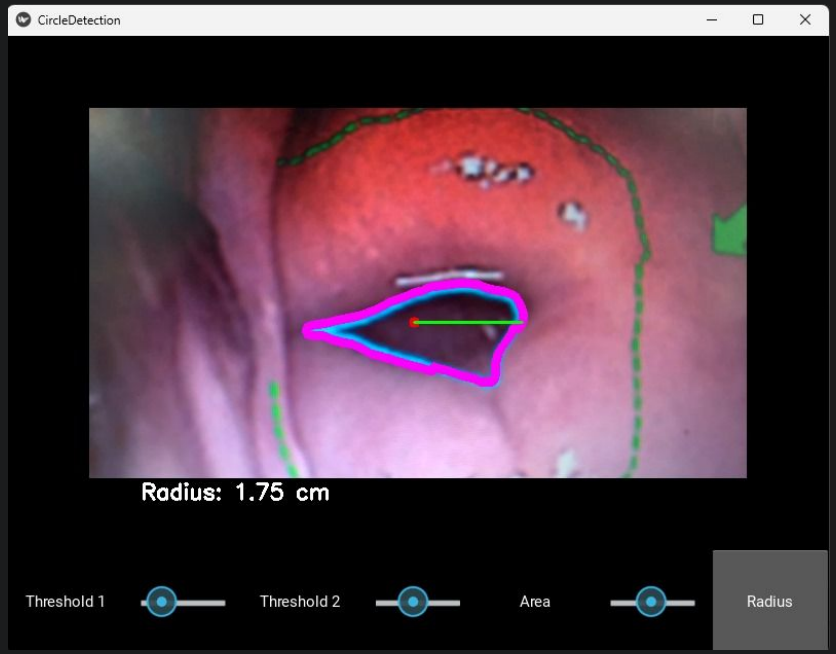
Develop models to accurately estimate cervical dilation progression.

Image processing Approach






Atlas of visual inspection of the cervix with...
960 × 720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Threshold 1
Threshold 2
Area
Radius