Workshop 1

1. Basics of CTG

- **What is CTG?**
  A monitoring technique during pregnancy and labor that records **fetal heart rate (FHR)** and **uterine contractions (UC)** to assess fetal well-being.
- **Why it matters:**
  The fetus can experience hypoxia (lack of oxygen). CTG aims to detect early warning signs so doctors can intervene before serious harm (brain damage, stillbirth).
- **Main signals measured:**
  - **Baseline FHR (LB)**: Average heart rate (usually 110–160 bpm).
  - **Accelerations (AC)**: Short-term increases in FHR → sign of healthy fetus.
  - **Decelerations (DS, DP, DR, DL, ASTV, MSTV, etc.)**: Drops in FHR; can indicate stress.
  - **Variability**: Natural fluctuations in heart rate; low variability = possible distress.

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2. Advanced CTG Terms

- **Short-Term Variability (STV):**
  Beat-to-beat fluctuations in FHR.
  - **High STV →** fetus adapting well.
  - **Low STV →** possible hypoxia, acidosis.
- **Long-Term Variability (LTV):**
  Broader oscillations over minutes. Normal fetus should not have a “flat” line.
- **Decelerations (types):**
  - **Early decelerations**: Mirror contractions → usually benign.

- **Late decelerations**: Start *after* contraction → concerning, may signal placental insufficiency.
- **Variable decelerations**: Abrupt dips → cord compression.
- **Prolonged decelerations**: >2 min → dangerous if persistent.

- **Pathological patterns:**
  - Repeated late decelerations.
  - Reduced variability.
  - Sinusoidal FHR (smooth wave pattern → severe anemia or hypoxia).

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3. **Design Choice Terms (Why These Features (or inputs) Matter)**

- **Baseline FHR (LB):**
  - Normal 110–160 bpm.
  - <110 = bradycardia (may indicate hypoxia).
  - 160 = tachycardia (infection, maternal fever).
- **Accelerations (AC):**
  - Presence = healthy autonomic response.
  - Absence (especially with other abnormalities) = warning sign.
- **Variability (MSTV, ASTV):**
  - Normal = “wiggly line.”
  - Abnormal = “flat CTG,” may suggest hypoxia or CNS depression.
- **Decelerations (DS, DP, DR, DL):**
  - Their timing and shape distinguish harmless vs harmful conditions.

In ML terms: each feature is a clinical signal doctors already use. The challenge is whether a model can learn **combinations** of these features better than humans do under pressure.

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4. Conceptual Flow (How Doctors Interpret CTG)

When reading a CTG, clinicians typically follow:

1. **Baseline**: Is it within 110–160?
2. **Variability**: Is the line wiggly or flat?
3. **Accelerations**: Are there enough accelerations?
4. **Decelerations**: Are they early, late, variable, or prolonged?
5. **Overall pattern**: Normal, suspicious, or pathological.

This matches the dataset labels:

- **Normal** → Reassuring baseline, good variability, accelerations present, no concerning decelerations.
- **Suspect** → Some abnormalities (e.g., reduced variability, occasional late decelerations).
- **Pathologic** → Multiple warning signs (flat trace, recurrent late decelerations, abnormal baseline).

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5. General Diagnostic Terms in a Medical Setting

- **Normal CTG:** Fetus well-oxygenated. Continue routine monitoring.
- **Suspicious CTG:** Possible compromise. Need closer observation, repeat testing.
- **Pathological CTG:** Likely compromise. Immediate action (C-section, oxygen, maternal repositioning).

In ML evaluation:

- **False Negative (missed pathology):** Most dangerous model says “normal” but baby is in distress.
- **False Positive (false alarm):** Less dangerous but still problematic (unnecessary interventions).

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6. Connecting Medical Theory to ML Parameters

- **Imbalance problem:** In real hospitals, “Normal” cases vastly outnumber “Pathologic.” Models must avoid ignoring rare but critical outcomes.
- **Interpretability:** Doctors need explanations like “low variability + late decelerations = high risk.” Black-box models risk rejection.
- **Output preferences:** Models that give **probability scores** (not just yes/no) align better with medical decision-making (risk-based).

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7. Quick Example of Diagnostic Interpretation

- **Case:** LB = 180 (tachycardia), Variability = low, AC absent, late decels present.
  - **Doctor’s read:** Pathologic CTG, immediate action.
  - **ML read (ideal):** Predict “Pathologic” with high probability.
- **Case:** LB = 140, Variability = normal, AC present, no decels.
  - **Doctor’s read:** Normal.
  - **ML read (ideal):** Predict “Normal.”
