Algorithm for Semi-Automatic Detection and Computational Analysis of Harris Lines in X-Ray Images

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What are Harris Lines?

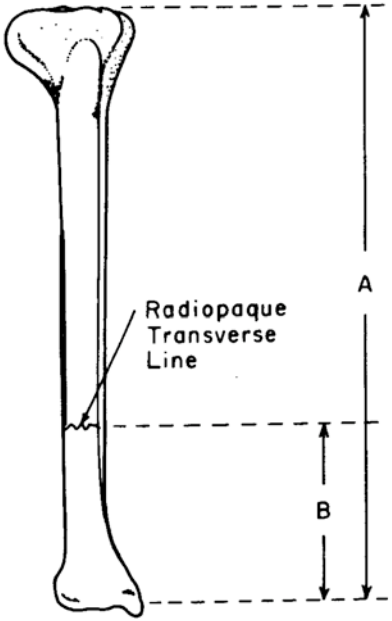
- **Harris, 1933:**
  Radio-opaque transverse lines in x-rays of long bones
- **Harris lines are generally correlated with a period of stress (e.g. infectious diseases, malnutrition) during bone growth**
- **E.g. provide information on health and living conditions of past populations**

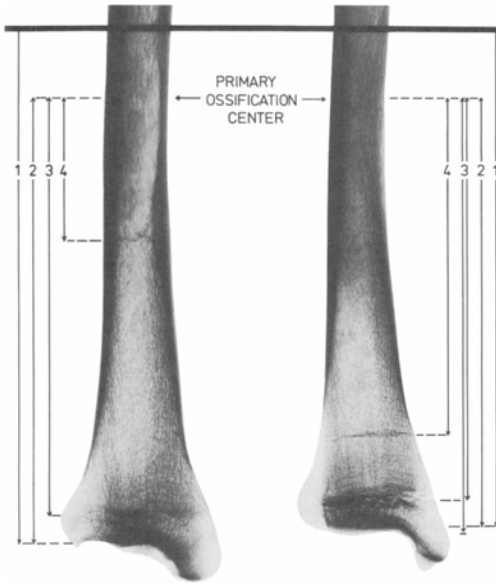
Criteria for Harris Lines Detection

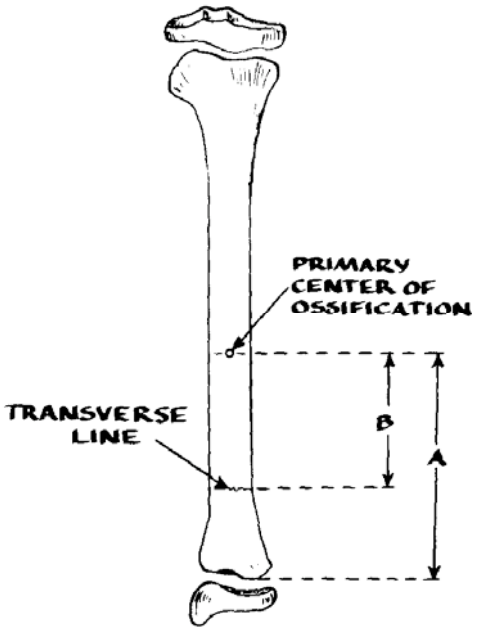
- **Standard: Garn et al., 1968, and Gindhart, 1969:**
  - **Visible by naked eye**
  - **Extend at least halfway accross the diaphyses**
  - **Use proximal and distal Harris lines:**
    - **Distal Harris lines are primary**
    - **Proximal Harris lines are secondary**
- **Clarke & Mack, 1988:**
  - **Must cover at least 30% of the shaft width**
  - **Angles must be greater than 45° and less than 135°**
- **Maat, 1984:**
  - **Type I: Harris line only detectable by careful inspection**
  - **Type II: Moderate lines in metaphyses**
  - **Type III: Moderate lines in diaphyses; strong ones in metaphyses**

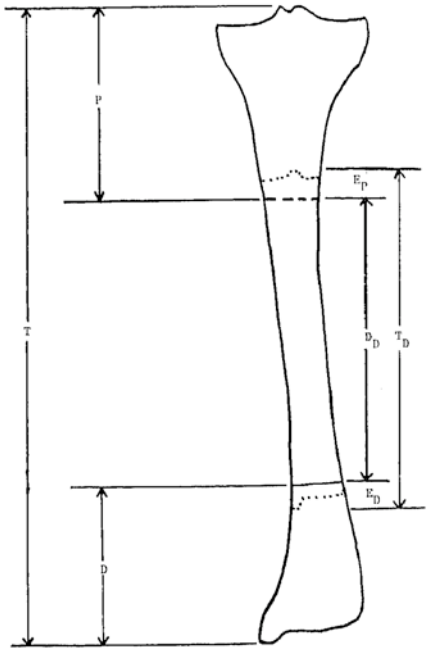
State of the Art Methods

- **Goal: Determine the individual's age at line formation**







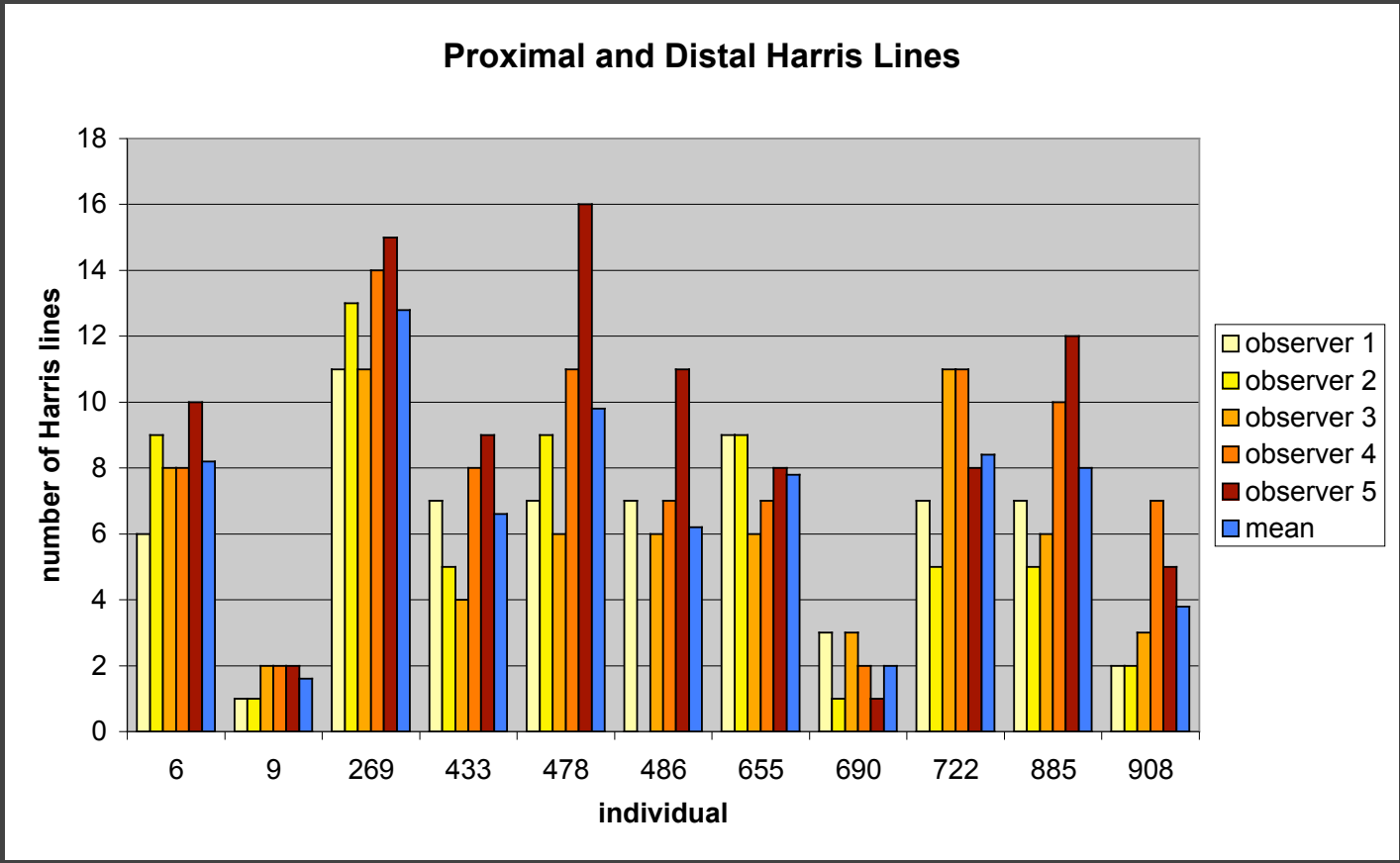


Clarke, 1982 Maat, 1984 Hummert & van Gerven, 1985 Byers, 1991

Problems of Automatic Detection

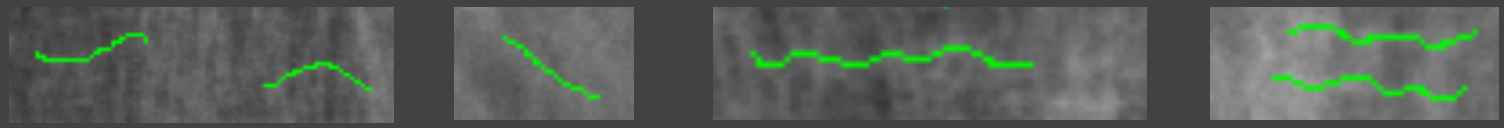
- **What is a Harris line?**
- **Intra- and interobserver variability high**

Interobserver Variability

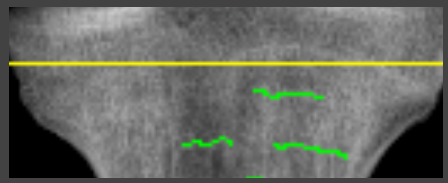


Problems of Automatic Detection 2

- Epiphyseal fusion appears as a line
- Other trabecular structures are similar to Harris lines



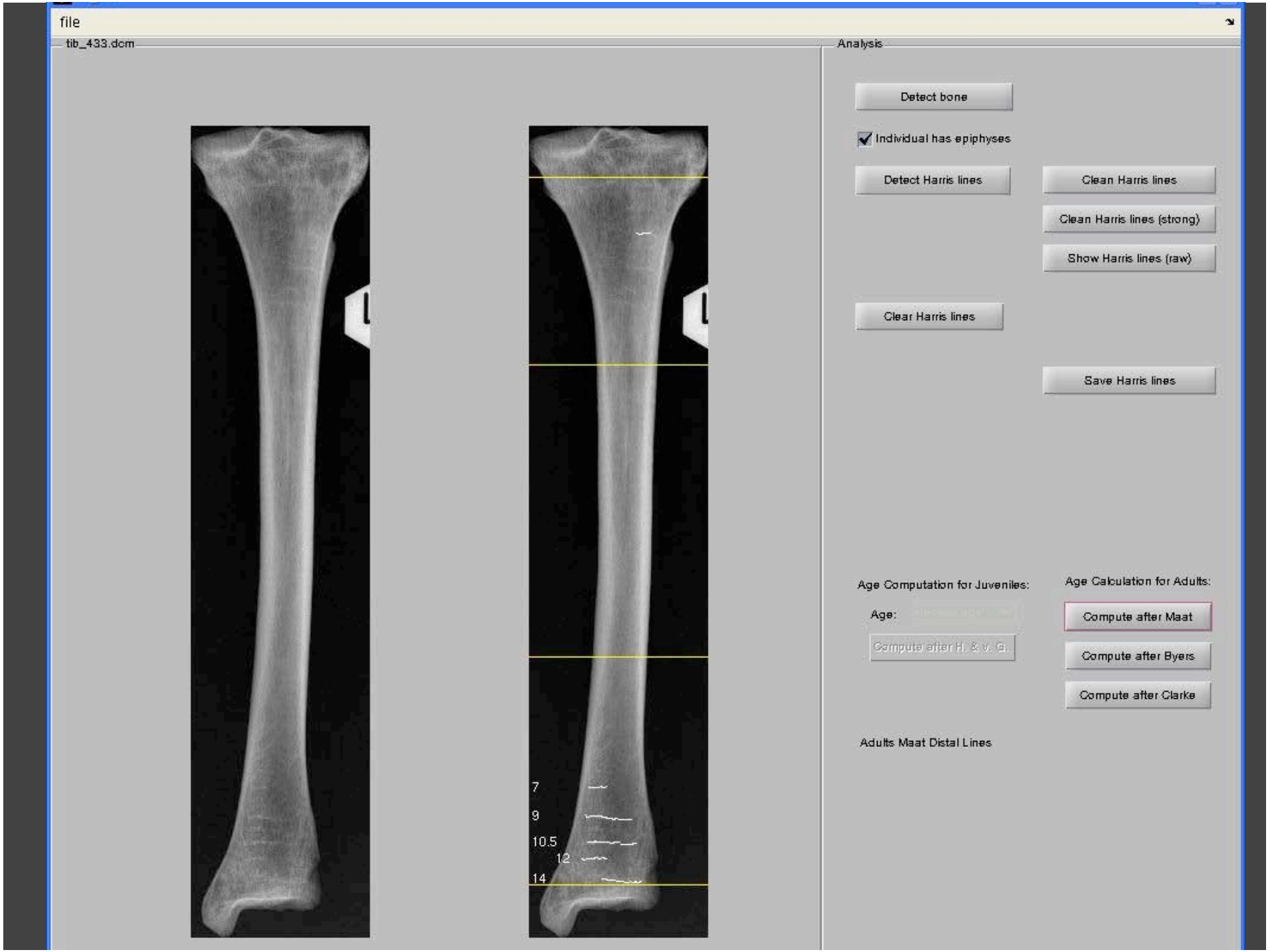
- Harris lines close to epiphyses follow the shape of the epiphyseal fusion (no horizontal lines)



- Projection errors during x-ray imaging
- Combine several lines to one Harris line

Algorithm

- Mode with or without epiphyses
- Detect bone:
  - Orientation
- Line detection algorithm that finds horizontal lines (Koller et al. , 1995)
- Parameters:
  - Minimal line length according to shaft width (1/2 or 1/3)
  - Angle of Harris lines according to bone orientation
  - Curly lines are excluded
  - Lines in epiphyses are excluded
- Classify lines into 2 groups
- Compute age of line occurrence according to selected method

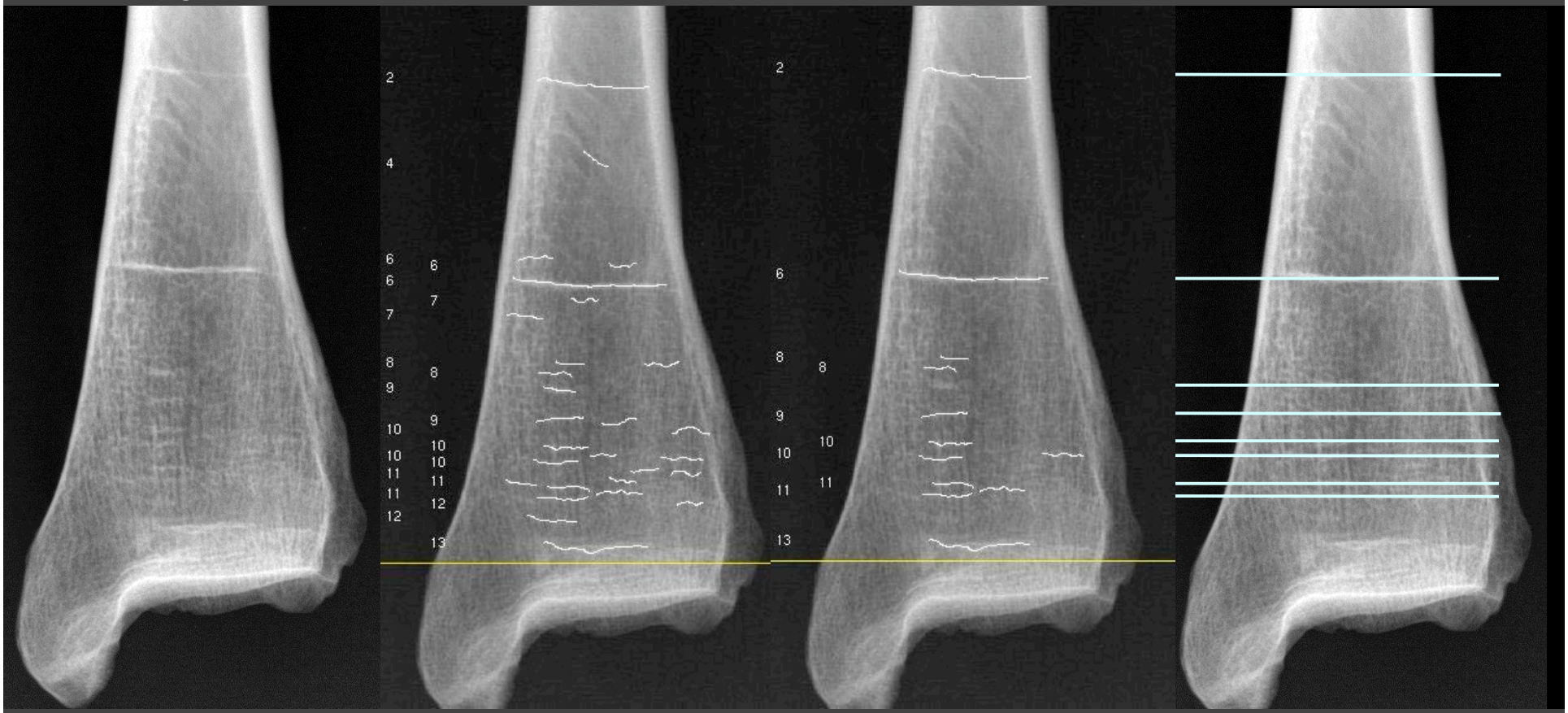

file
tib_433.dcm
Analysis
Detect bone
Individual has epiphyses
Detect Harris lines
Clean Harris lines
Clean Harris lines (strong)
Show Harris lines (raw)
Clear Harris lines
Save Harris lines
Age Computation for Juveniles:
Age:
Compute after H. & v. G.
Age Calculation for Adults:
Compute after Maat
Compute after Byers
Compute after Clarke
Adults Maat Distal Lines
7
9
10.5
12
14

Material

- **Population: Tomils-Sogn Murezi, GR, Switzerland**
- **Tibiae of 12 individuals**
  - **11 x left, 1 x right**
  - **f, m**
  - **juveniles and adults**
- **Digital x-rays (12 bit): anterior-posterior Orthopedic University Clinic Balgrist Zürich**

Sample Distal Harris Lines

Original | Automatic 1 | Automatic 2 | Observer 5



Age of Harris line occurence computed by Byers, 1991.

Workgroup Applied Anatomy – Institute of Anatomy – University of Zürich

Sample Proximal Harris Lines

Original | Automatic 1 | Automatic 2 | Observer 5

Age of Harris line occurence computed by Byers, 1991.

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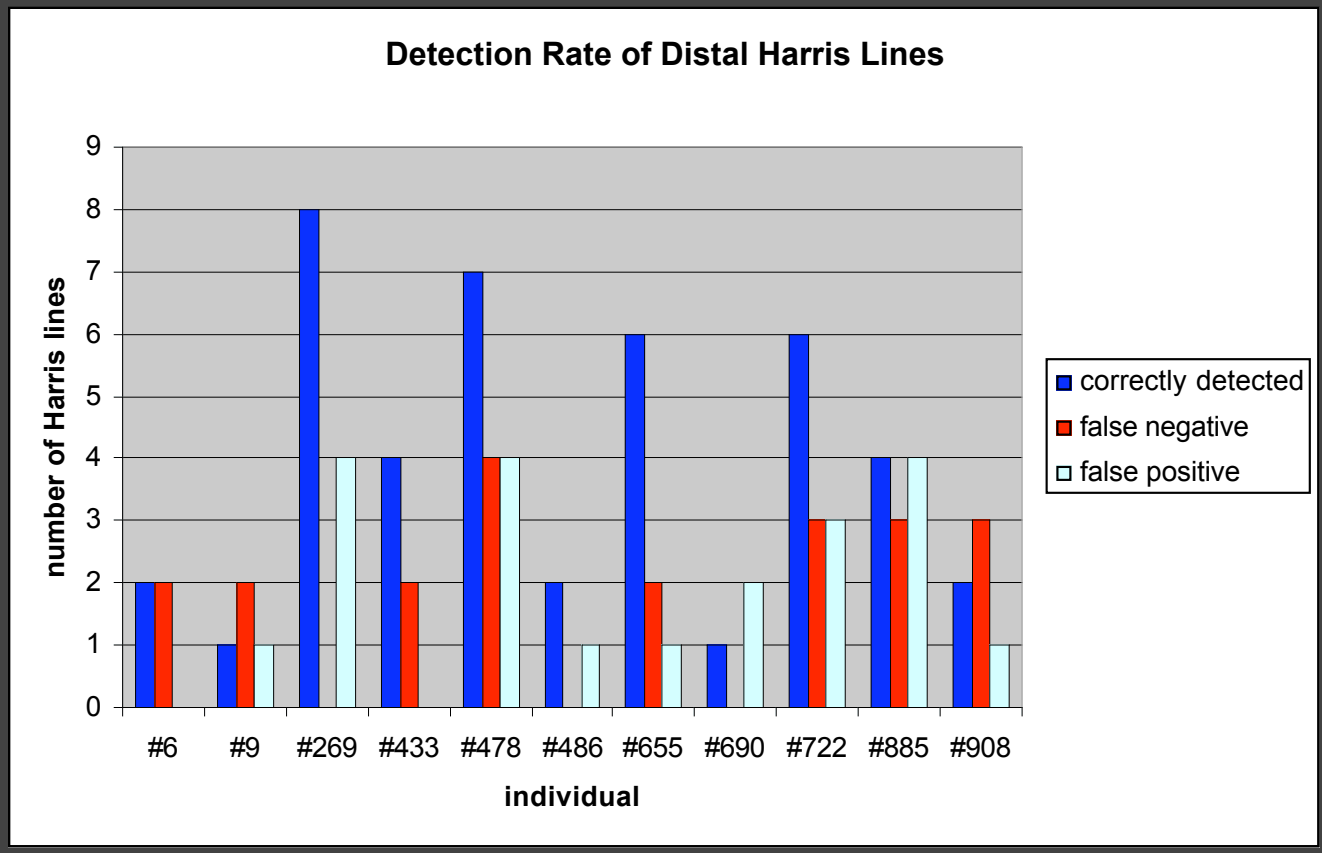
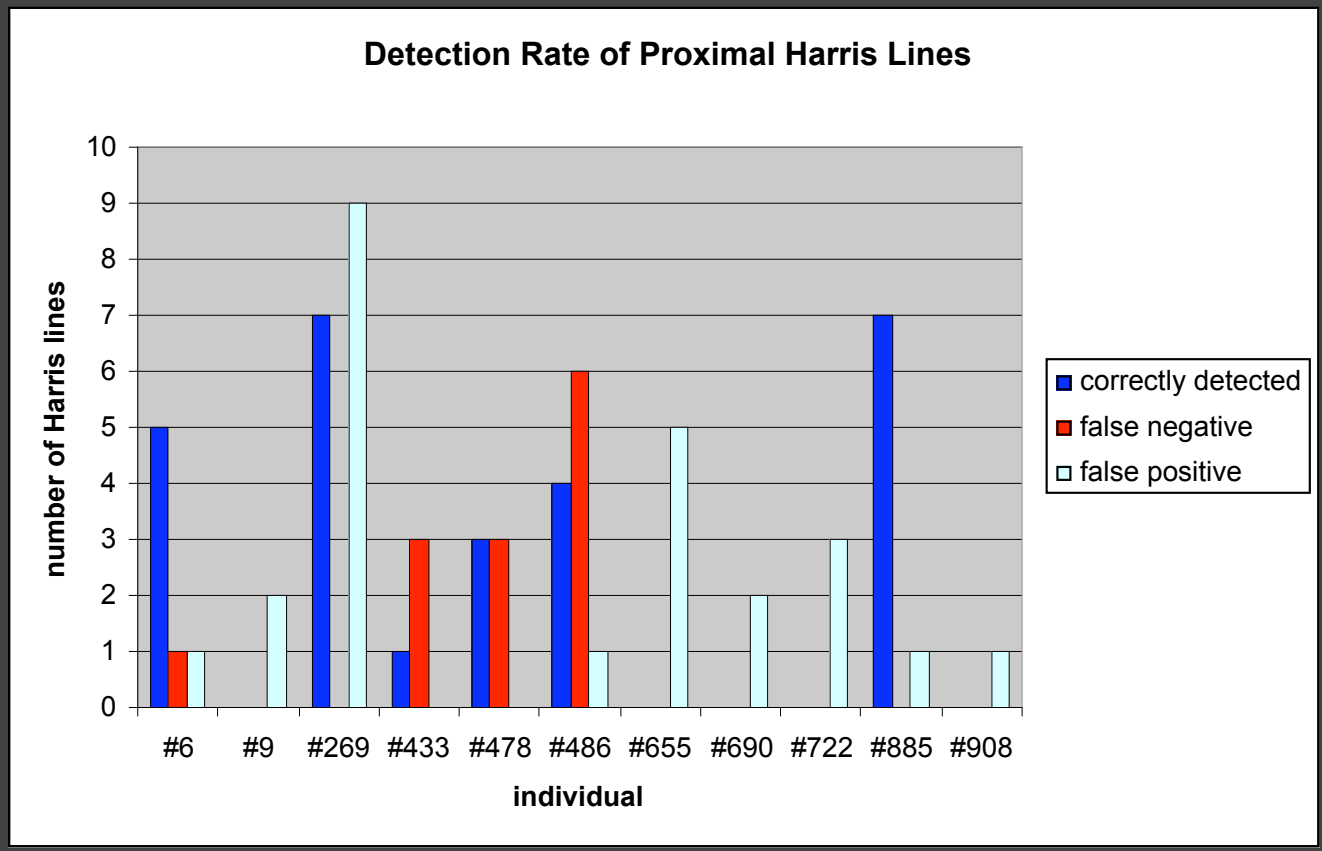
Manual vs. Automatic Detection



Reference for „correct“ Harris lines: observer 5

Manual vs. Automatic Detection



Reference for „correct“ Harris lines: observer 5

Relevance and Perspective

- Intra- and inter-observer error is high
- Semi-automatic detection
- Classification into two segments
- 4 different standard methods for computational analysis
- Shorter data acquisition

Announcements

- **Demo application on a laptop at conference**
- **Harris lines workshop at Institute of Anatomy, Zürich University**
  Friday: December, 7th, 2007
  Contact: frank.ruhli@anatom.uzh.ch

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