CMPE 233: Human Factors

Ergonomics Science

Workplace Safety

Electrical Safety

Medical & First Aid

Lockout/Tag-out

Ergonomics

Asbestos Control

Confined Space

Fire Prevention

Personal Protective Equipment

Hazard Communication

Chemical Safety

Ergonomics

- The science and practice of designing jobs or workplaces to match the capabilities and limitations of the human body
- Benefits of ergonomics:
  - safer jobs, fewer injuries
  - increased efficiency & productivity
  - improved quality and fewer errors
  - improved morale
- Violations of ergonomics:

  Musculoskeletal Disorder (MSD)
  - a disorder of the muscles, nerves, tendons, ligaments, joints, cartilage, blood vessels or spinal discs

Musculoskeletal Disorders

Total musculoskeletal disorders 487.9 9 (1,000's)

Occupations	Number	Median Days AFW
Nursing aides, orderlies, and attendants	44.4	6
Truck drivers	36.8	12
Laborers, nonconstruction	24.9	8
Janitors and cleaners	15.2	7
Assemblers	15.2	14
Construction laborers	11.1	10
Registered nurses	10.8	6
Supervisors and proprietors, sales occupations	9.9	7
Cashiers	9.3	8
Stock handlers and baggers	8.8	5
Sales workers, other commodities	7.8	7

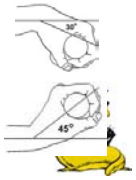
WMSD (Workplace MSD)

- Exposure to "Caution Zone Job"
  - Awkward postures
  - High hand force
  - Highly repetitive motion (more than 4 hr/day intensive keying)
  - Repeated impact
  - Heavy, frequent or awkward lifting
  - Moderate to high hand-arm vibration

- Requirements for caution zone job:
  - Awareness education
  - Evaluate caution zone jobs for hazard
  - Reduce exposure below the hazard level or to the degree feasible

Awkward Posture

- More than 2 hours total per day with:
  - Hands above head, hands bent
  - Elbow above shoulder
  - Back bent forward more than 30 degrees
  - Neck bent more than 30 degrees
  - Squatting
  - Kneeling

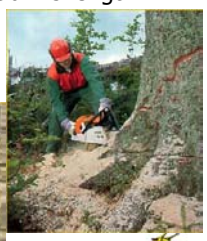


Others

- High hand force: more than 2 hours a day of
  - Pinching 2+ lbs weight or 4+ lbs force
  - Gripping 10+ lbs weight or force
- Repeated impact: using hands or knees as hammer
  - more than 10 times per hour
  - more than 2 hours per day

Others

- Lifting objects more than:
  - 75 lbs once/day
  - 55 lbs more than 10x/day
  - 10 lbs more than twice/minute for more than 2 hr/day
  - 25 lbs above shoulders, below knees, or at arms length for more than 25x/day
- Hand/arm vibration
  - Moderate level more than 2hr/day
  - High level more than 30 min/day

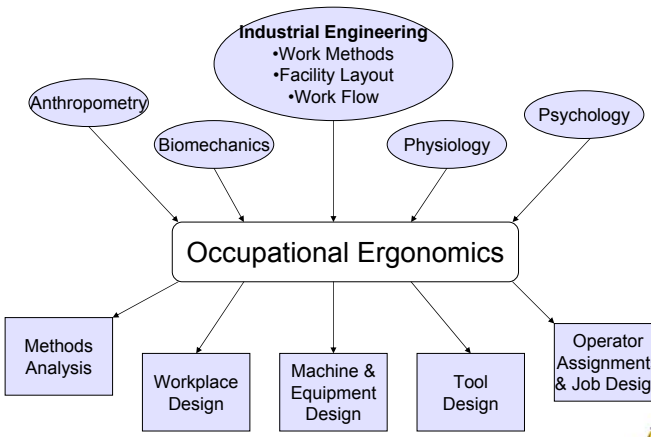


Risk Factors → Hazards

- There is a longer duration of exposure than allowed
- There is greater intensity (40º)
- There is a combination of risk factors
- Minimizing hazards → use a systematic method to look at:
  - physical demands
  - layout of work area
  - size, shape, and weight of objects handled
- Some solutions
  - Foot control combined with mouse control
  - Lifting assistive devices
  - Shoulder harness

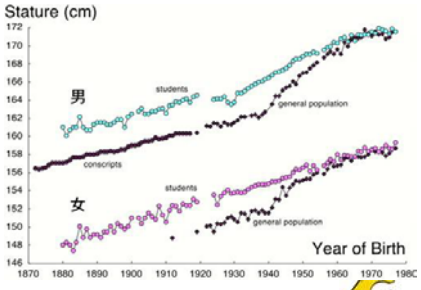
Our body is pretty smart

	Strong Evidence	Evidence	Insufficient
Force	Back	Neck, Elbow CTS, Hand/wrist tendinitis	Shoulder
Posture	Neck	Shoulder, Hand/wrist tendinitis, Back	Elbow CTS
Repetition		Neck, Shoulder CTS, Hand/wrist tendinitis, Back	Elbow



Anthropometry

- A science that deals with the measurement of size, weight, and proportions of the human body. It is empirical (experimentally derived) in nature and has developed quantitative methods to measure various physical dimensions
- Human variability:
  - Size
  - Range of motion
  - Strength
  - Endurance
  - Stress tolerance
  - Intelligence
  - Dexterity
- Affected by environment as well as genetic



History of Anthropometry

- 1883- Alphonse Bertillon: system of identification depending on the unchanging character of certain measurements of parts of the human body
- 1884: 241 multiple offenders were identified
- "Bertillonage"- first adapted by the French police
- 1887: introduced in the US by Major McClaughry, the translator of Bertillon's book, when he was the warden of the Illinois State Penitentiary at Joliet.
- 1888: Francis Galton starts research on "Finger Prints" to further anthropometry
- 1892: Francis Galton publishes *Finger Prints*
- 1894: England adopted the system.

How it's used in history

- Identification of repeated criminals
  - Cesare Lombroso's *Criminal Anthropology* (1895): "murderers have prominent jaws and pickpockets have long hands and scanty beards".
  - Eugene Vidocq: identification of criminals by facial characteristics
- Prevention of impersonation
- Differentiation between the races
  - Eugenics in Europe
- Intelligence tests became associated with anthropometry
- General Problems with Anthropometry:
  - Cost and error of the instruments used
  - Education needed to be able to take the measurements
  - Error in calculation and measurements

Measurement

- Static measurements
  - Measurements taken when body in a fixed state
  - Skeletal dimensions (between the centers of joints, i.e.. between elbow and wrist)
  - Contour dimensions (skin surface/head circumference)
  - Body measurements vary as a function of age, gender, ethnicity (and nutrition, but not as clear)
  - Data available – NASA Anthropometric Source Book
- Dynamic (Functional) Dimensions
  - Taken when body is engaged some physical activity
  - Body members function in concert
- No systematic procedure for translating static into dynamic measurements

Measurement

- Weight
- Stature
- Posture:
  - Standing
  - Frankfort
  - Sitting
- Arm Span
- Head Length
- Head Breadth
- Ear-to-Head Height
- Nasal Length
- Nasal Breadth
- Skeletal Index = Sitting Height x 100/Stature
- Cephalic Index = Head Breadth x 100/Head Length
- Nasal Index = Nasal Breadth x 100/Nasal Length
- Span/Stature Index = Arm Span x 100/ Stature
- Cranial Capacity

Anthropometric Design Principles

- Designing for the average
  - Typical/default (restaurant seating)
  - Cheapest but least preferred
  - ADA accommodations
- Designing for the extremes
  - Doorways: what dimension/factors?
  - Reach distances (controls) – what percentile?
- Designing for the range
  - Fit a wide range of individuals - ADJUSTABILITY
    - 5th percentile female to 95th percentile male
    - 5' female to 6' 2" male
  - Inclusive design principles
  - Adaptability (most expensive but most preferred)

Anthropometric Design Guidelines

- Determine body dimensions important in design (sit height as basic factor in seat-to-roof in automobiles)
- Define population to use the equipment/facilities
- Determine what principle should be applied (extremes, average or adjustable ranges)
- When relevant, select % of users served (90%, 95%) whatever is relevant to the problem
- Use anthropometric tables appropriate for the population, & use data
- For special clothing, add appropriate allowances (winter jacket restricts reach by approximately by 2")
- Build full-scale mock-up of equipment/facility & use it w/user population
- All the anthropometric data in the world cannot substitute for a full-scale mock-up

(Sanders, McCormick)

Principles of Arranging Components

- General Guidelines
  - Importance Principle - degree the component is vital to the achievement of the objectives of the system
  - Frequency-of-Use Principle - Frequently used components be place in convenient locations
  - Functional Principle - Grouping of components according to function
  - Sequence-of-Use Principle - Sequences or patterns of relationship frequently occur in the operation of equipment or in performing some service or task
- Work-Space Envelope
  - Seated: effects of direction of reach
  - Standing: body equilibrium, reach range
  - Reasonable limits of space are determined by functional arm reach, influenced by: direction of arm reach, task, use of restraints, clothing, backrest angle and personal variables

Principles of Arranging Components

- Work surface
  - Make it adjustable where possible (legs/feet, slant)
  - Forearm should be level of slightly down with shoulders relaxed (not hunched)
  - Allow for a "straight" spine (posture) to reduce strain and fatigue in the back muscles/spine
  - Precision work: work level even with or slightly above elbow height
  - Heavy work: work level should be below elbow height
- Seating
  - Back support should be used: lower support most critical; lordotic (concave) preferred over kyphotic (convex)

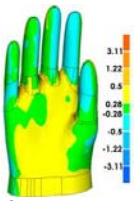
ANSI Standard for Seating

- Seat Height and Slope:
  - fixed height: 18 - 19”
  - adjustable height: 16 - 20.5”
  - slope: 0 - 10º backward tilt
- Seat Depth and Width:
  - depth: 15 - 17”
  - width: 18.2”
- Contour and Cushioning:
  - contour: tradeoffs between even weight distribution vs. restricting movement and postural fixity.
  - cushion: 1.5 - 2” thick.
- Seat Back:
  - angle: minimum 90 - 105º with respect to the seat pan. Up to 120º prefered.
  - width: minimum 12” in the lumbar region.
  - height: minimum 19.5”.
  - lumbar support: 6 - 9” high, 12” wide, positioned 6 - 10” above seat reference point, and protrude ~ 2” from back rest.

Anthropometric design of glove

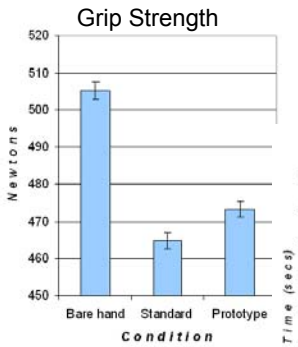
- Project funded by UK Military
- Use of anthropometry to design handwear with increased fit
- Generation of CAD models using hand anthropometry
  - Geometric shapes generated to represent different parts of the hand
- Use of CAD models to produce dip moulding (non-woven manufacturing technique using a former to produce the shape of the glove)
- User trials to test finger dexterity & tactile perception

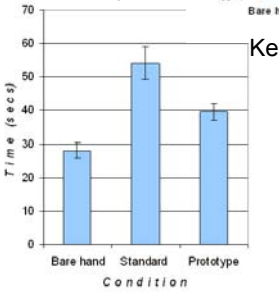
Anthropometric design of glove

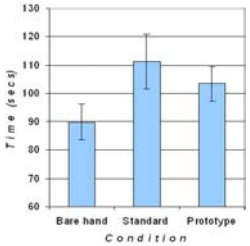


- 8 male subjects used to evaluate prototype gloves, selected by matching to size data
- Compared against bare hands & standard glove
- Series of dexterity tests
  - Peg Board Test
  - Nut & Bolt Assembly
  - Pin Pick Up Test (BS EN 420)
  - Keyboard Typing Test
  - Grip & Pinch Strength

Glove evaluation







Keyboard Typing Test

Modern anthropometry

- Cranial Anthropometry/Craniometry
  - measurement of the skull and face
  - Mostly done to observe child's development
  - 3 ways to categorize the skull
    - dolichocephalic: long and thin
    - brachycephalic: short and broad
    - mesocephalic: intermediate length and breadth
- 3- D Anthropometry
  - Cyberwar: DigiSize, CySlice, Ear Impression 3-D Scanner
  - SizeUSA: 3D measurement system, a body scanner feeding data into measurement extraction software.
  - CAESAR: generate a database of human physical dimensions for men and women of various weights, between the ages of 18 and 65
  - Virtual Models: virtually try on clothes, makeup etc.

Biometrics

- the automatic identification of a person based on his/her physiological or behavioral characteristics
- Verification vs. identification
  - Verification: *Am I whom I claim I am?* involves confirming or denying a person's *claimed identity*
  - Identification: *Who am I?*
- Forensics: criminal identification and prison security
- Prevention of unauthorized access to ATMs, cellular phones, smart cards, desktop PCs, workstations, and computer networks
- Automobiles: replace keys with key-less entry and key-less ignition
- Border control and national ID cards

Biometrics Authentication Process

- Biometrics Authentication Process
  - Acquisition
  - Creation of Master characteristics
  - Storage of Master characteristics
  - Data acquisition(s)
  - Comparison
  - Decision
- To improve reliability
  - Timeliness/liveness testing
  - Tamper resistance test
  - Secure communication test
  - Security threshold level test
  - Fall back system test

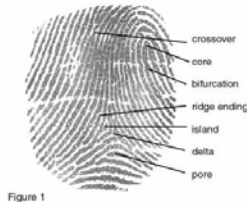
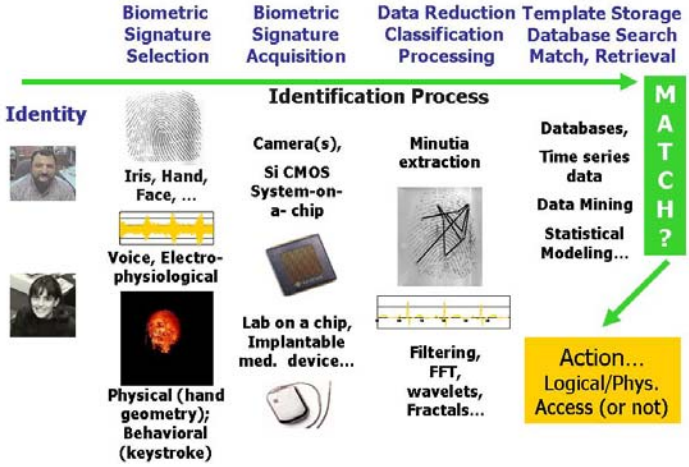


Figure 1

Automated Biometric Identification



Biometrics Programs

- Fingerprint Identification
- Hand Geometry: geometric shape of the hand for authenticating a user's identity
- Face Location: an arbitrary black and white, still image, find the location and size of every human face
- Multibiometrics: integrates face recognition, fingerprint verification, and speaker verification in making a personal identification

INSPASS: Hand Geometry


FacePass: Face Verification


Heathrow Airport- Iris

Biometrics Standards

- After 9-11, there is an increased emphasis on biometrics standards.
- Critical Infrastructure protection and Homeland Defense/Security requested ITL (Information Technology Laboratory) of NIST (National Institute of Standards and Technology) for standards
- INCITS Biometric Technical Committee M1 was formed (2002)
  - 42 members from private industry, government agencies and academia
  - Data interchange format (finger, face, iris, signature, hand geometry)
  - Applications: transport workers, border management, POS
  - Standardization of biometric performance metric definitions and calculations, approaches to test performance and requirements for reporting the results of these tests

Usability Metrics

Failure to enroll (FTE)

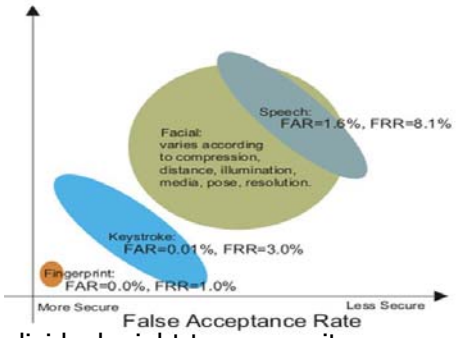
- the technology is unable to read the characteristics of a given person.
- based upon the quality of the data obtained
- Hoarseness
- Sticky fingers
- Cataract

Failure to acquire (FTA)

- the technology is not presented with sufficient usable data to make a decision
- Smudged finger prints
- Retina alignment
- Mumbling
- Hand positioning

- False Acceptance Rate (FAR): The rate non authorized person is accepted as authorized
- False Rejection Rate (FRR): The rate authorized person is rejected access
- Equal Error Rate: where FAR and FRR crossover

Performance Metrics



- Plus: Threatens individuals right to anonymity
  - Cultural concerns
  - Religious concerns
  - Violates civil liberties
- Biometrics are not secrets and are therefore susceptible to modified or spoofed measurements

Useful Biometrics

- Universality: Every person should possess this characteristic
- Uniqueness: No two individuals possess the same characteristic.
  - Genotypical – Genetically linked (e.g. identical twins will have same biometric)
  - Phenotypical – Non-genetically linked, different perhaps even on same individual
- Permanence: The characteristic does not change in time, that is, it is time invariant
  - Degree of permanence has a major impact on the system design and long term operation of biometrics. (e.g. enrollment, adaptive matching design, etc.)
- Collectability: The characteristic can be quantitatively measured
- Acceptability? Intrusiveness? Time? Reliability?

Issues with Biometrics

- Is the biometric data like personal information (e.g. such as medical information) ?
- Can medical information be derived from the biometric data?
- Does the biometric system store information enabling a person's "identity" to be reconstructed or stolen?
- Is permission received for any third party use of biometric information?
- What happens to the biometric data after the intended use is over?
- Is the security of the biometric data assured during transmission and storage?
- How is a theft detected and "new" biometric accepted?
- Notice of biometric use. Is the public aware a biometric system is being employed?