An Ontology of Measurement Units and Dimensions

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Outline of Talk

- Why an ontology of units & dimensions?
- Units vs. dimensions
- The space of dimensions
- Coordinates vs. interval measures
- Torque vs. Work
- Concentration Measurements
- References
- Contact Info

Why an ontology of units & dimensions?

- Specification of measurement units & conversion between various units is essential for:

  - Science

  - Engineering

  - Manufacturing

  - Commerce

  - Medicine

  - Environmental Regulation

Base Dimensions and Units

- Mass: kilogram (kg)
- Length: meter (m)
- Time: second (sec)
- Current: Ampere (A)
- Temperature: Kelvin (K)
- Amount of substance: Mole (mol)
- Intensity of light: candela (cd)
- Note: 7 base dimensions

Units and Dimensions

- A "meter" is a unit of "Length" (the dimension)
- A "kg" is a unit of "Mass"
- Dimension = the underlying property
- Unit = A "quantum" of a dimension
- Dimension = equivalence class of units
- Length = ec (feet, meters, inches, miles, …)
- Measurements of same dimensionality can be converted from one measurement unit to another.

Derived Dimensions (units)

- Length = base dimension (meters)
- Area = L**2 (square meters)
- Volume = L**3 (cubic meters)
- Density = mass / volume = M/L**3
- Energy = force * distance = M * L**2 / T**2

The space of dimensions

- Seven base dimensions:
  - M, L, T, current, temp, amt, intensity of light
- Exponents
  - From -3 to +3
- Hence size of dimensionality space =
  - 7**7 = 823543 possible dimensions
  - Obviously not all of these are in actual use

Dimensional Analysis

- There is an algebra of dimensions

- Multiply quantites ==> multiply dimensions

- Divide quantities ==> divide dimensions

- Add / subtract quantities ==> must have same dimensions (but units may differ)

Concentration measurements

- SI units = moles / meter**3

- More commonly:

  - Moles / Liter = molarity

- Dimensionless concentration = ratio

  - Mass ratio

  - Mole ratio

  - Volume ratio

  - Partial pressure ratio

  - Usually not specified (most commonly mass ratio)

Concentration Ratios

- Conversion of mass, mole, volume, pressure ratios is material dependent (also state (temp, pressure) dependent

- Standard dimensional analysis treats all dimensionless quantities the same

- This does not work for concentration ratios

Torque vs. Work

- Work (energy) = Force * Distance
  - Actually the dot product of F*d
- Torque = Force x Distance
  - Actually the vector cross product
- Both work, torque have units of Newton * meters
  - Scalar representation is insufficient

Coordinates vs. Interval Measures

- Interval measure = measurement magnitude
- Coordinate:
  - Frame of reference
  - Magnitude
  - Direction (+/-)
  - Example: temperature
    - Interval measure = temperature difference across a wall
    - Coordinate = air temperature
    - Different conversion function (interval=multiply, coordinate = affine transformation (adjust for zero pt.))

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