

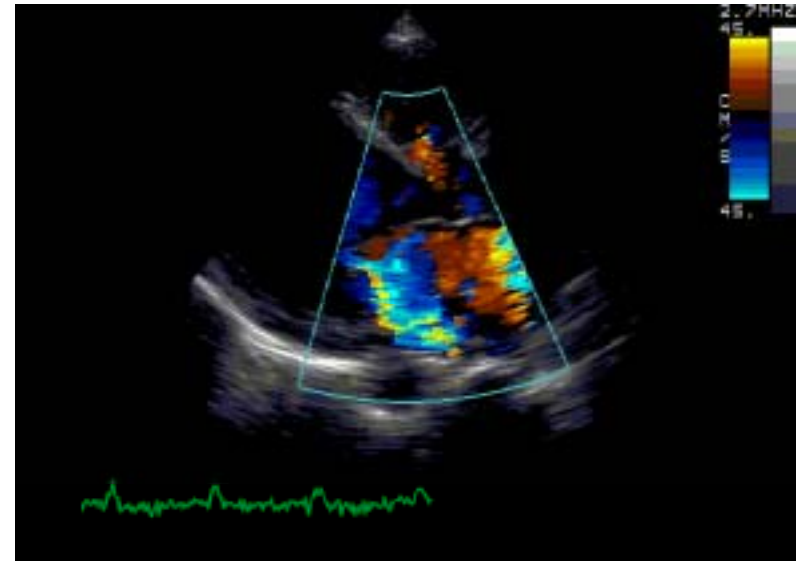
# Physical Unit Specification in Web3D

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# Requirements of Physical Property Units

- Precise object representation in science and engineering fields
- Comparable object description with unit specification
- Applications
  - CAD design unit
  - Physical engine in game
  - Medical visualization unit
  - 3D GIS in real units
  - Microorganism unit
  - Astronomical unit



Medical visualization (DICOM)

# Physical Property Units

- Objectives
  - Define physical property units (measurement units) in Web3D
  - Define an X3D component for including the physical units
- Kinds of physical properties
  - The international standard SI units
    - length, mass, time, electric current, thermodynamic temperature, amount of substance, luminous intensity
  - Additional units definition
    - area, volume, sound pressure

# Physical Property Units

SI base units<sup>[6]</sup>

Name	Symbol	Quantity
metre	m	length
kilogram	kg	mass
second	s	time
ampere	A	electric current
kelvin	K	thermodynamic temperature
mole	mol	amount of substance
candela	cd	luminous intensity

- Length and other physical units
  - Length units: visually precise scaling
  - Other units: informative

# Physical Length Units

- **Physical Length Properties and Units**

- Define length measurement units in X3D
- Coordinates of an X3D object should be updated by transforming them according to the unit defined
- Advantages
  - Precise representation of an object's length or the distance between two objects using length units
- Differences from scaling
  - Capability of comparing objects' real sizes or recognizing real distances between two objects
  - Different from general relative scaling transformation

# Physical Property Unit Component

- X3DPhysicalNode

1. Below X3DNode

*X3Dfield*

*X3DMetadataObject*

2. Various node references for physical units

*X3DNode*

```
|
+- X3DphysicalNode +- Length
|                   +- Area
|                   +- Volume
|                   +- Mass
|                   +- Time
|                   +- Current
|                   +- Temperature
|                   +- Substance
|                   +- Luminous
|                   +- SoundPressure
|
+- X3DchildNode +- X3DshapeNode +- ParticleSystem
|                                     +- Shape
```

3. Derived from X3DShapeNode which is a child node of X3DNode

**Position of  
X3DPhysicalNode**

# Definition of a Physical Node

- **Physical Node**

- Defines the physical units for an object

```
Physical : X3DPhysicalNode {  
SFNode [in,out] Length      NULL [Length]  
SFNode [in,out] Area        NULL [Area]  
SFNode [in,out] Volume      NULL [Volume]  
SFNode [in,out] Mass        NULL [Mass]  
SFNode [in,out] Time        NULL [Time]  
SFNode [in,out] Current     NULL [Current]  
SFNode [in,out] Temperature NULL [Temperature]  
SFNode [in,out] Substance   NULL [Substance]  
SFNode [in,out] Luminous    NULL [Luminous]  
SFNode [in,out] SoundPressure NULL [SoundPressure]  
SFNode [in,out] metadata    NULL [X3DMetadataObject]  
}
```

- The field values can be NULL, or include an appropriate type node

# Definition of a Length Node

- **Length Node**

```
Length : X3DPhysicalNode {  
  SFString [in,out]  unit    “UNI” [“YOTTA”|“ZETTA”|“EXA”|“PETA”|“TERA”|“GIGA”|  
    “MEGA”|“KILO”|“HECTO”|“DECA”|“UNI”|“DECI”|“CENTI”|“MILLI”|“MICRO”|“NANO”|  
    “PICO”|“FEMTO”|“ATTO”|“ZEPTO”|“YOCTO”|“INCH”|“LINK”|“FT”|“YD”|“RD”|  
    “CHAIN”|“FL”|“MILE”|“LG”|“MIL”|“AU”|“LY”|“PC”|“KPC”|“NMILE”|“ANG”|“USER”]  
  
  SFFloat [in,out]  basis    “1”    [-∞ , ∞]  
  SFString [in,out]  numeral  “DEC” [“SCIEN” | “DEC” | “ENGIN” | “ARCH” | “FRAC”]  
  SFNode [in,out]   metadata  NULL [X3DMetadataObject]  
}
```

- The basic unit of a Length node is meter
- The unit field specifies a length unit
- The base field specifies the scale of measurement for the user defined length unit, based on meter equal to 1
- The numeral field specifies the kinds of notation for displaying numbers by the unit specification



# Numeral representation

<b>Numeral type</b>	<b>Numeral value</b>	<b>Examples</b>
<b>Scientific</b>	<b>SCIEN</b>	<b>1.5000E+00, 2.0039E+00, 0.0000E+00</b>
<b>Decimal</b>	<b>DEC</b>	<b>1.5, 2, 0</b>
<b>Engineering</b>	<b>ENGIN</b>	<b>1.5", 2", 0"</b>
<b>Architectural</b>	<b>ARCH</b>	<b><math>1 \frac{1}{2}</math> ", 2", 0"</b>
<b>Fractional</b>	<b>FRAC</b>	<b><math>1 \frac{1}{2}</math> , 2, 0</b>

# Examples of Unit Specification

```
<Scene>  
  <physical>  
    <length unit="INCH" basis = "1" numeral= "DEC"/>  
    <Transform scale="1 1 1" translation = "0 0 0">  
      <Shape>  
        [.....] // Coordinate  
      </Shape>  
    </Transform>  
  </physical>  
</Scene>
```

- A 3D facial model specified in inch unit
- Capable of defining its real size



# Definition of Other Physical Properties

- **Area**

- Specifies an area unit for the area composing an object
- The basic unit is square meter(m<sup>2</sup>)
- Located below the X3DPhysicalNode, and derived from X3DShapeNode
- The unit field specifies an area unit
- The value field specifies the value for an area

```
Area : X3DPhysicalNode {  
  SFString [in,out]  unit          "UNI2"  
  ["CENTI2"|"UNI2"|"FT2"|"YD2"|"HA"|"ACRE"]  
  SFFloat [in,out]  value          "1"  [-∞ , ∞]  
  SFNode [in,out]  metadata        NULL  [X3DMetadataObject]  
}
```

# Definition of Other Physical Properties

- **Volume**

- The volume node specifies the unit for an object's volume
- The basic unit is cubic meter(m<sup>3</sup>)
- Located below the X3DPhysicalNode, and derived from X3DShapeNode
- The unit field specifies the unit of a volume
- The value field specifies the value for a volume

```
Volume : X3DPhysicalNode {  
  SFString [in,out] unit          "UNI3"  
  ["CENTI3"|"UNI3"|"FT3"|"YD3"|"DL"|"ML"|"L"]  
  SFFloat [in,out] value         "1" [-∞ , ∞]  
  SFNode [in,out] metadata      NULL [X3DMetadataObject]  
}
```

# Definition of Other Physical Properties

- **Mass**

- The Mass node defines a mass unit for an object
- It is defined by SI (International System of Units) and the basic unit is kilogram(kg)
- Located below an X3DPhysicalNode, and derived from an X3DShapeNode
- The unit field specifies a mass unit
- The value field specifies a value for the mass unit

```
Mass : X3DPhysicalNode {  
  SFString [in,out]  unit      "KG"  
                    ["MG"|"G"|"KG"|"LB"|"TON"|"GRAIN"|"OZ"]  
  SFFloat  [in,out]  value     "1"    [-∞ , ∞]  
  SFNode   [in,out]  metadata  NULL   [X3DMetadataObject]  
}
```

# Definition of Other Physical Properties

- **Time**

- The Time node specifies the unit for time
- It follows SI (International System of Units) specification and the basic unit is second
- Located below an X3DPhysicalNode, and derived from an X3DShapeNode
- The unit field specifies a time unit
- The value field specifies a value for the time unit

```
Time : X3DPhysicalNode {  
  SFString [in,out]  unit      "S"      ["S"|"MIN"|"S"]  
  SFFloat  [in,out]  value     "1"      [-∞ , ∞]  
  SFNode   [in,out]  metadata  NULL    [X3DMetadataObject]  
}
```

# Definition of Other Physical Properties

- **Current Node**

- The Current node specifies the electric current unit for an object
- It follows SI (International System of Units) specification and the basic unit is ampere (A)
- Located below an X3DPhysicalNode, and derived from an X3DShapeNode
- The unit field specifies an electric current unit
- The value field specifies a value for the current unit

```
Current : X3DPhysicalNode {  
  SFString [in,out]  unit      "A"  
  SFFloat  [in,out]  value     "1"    [0 , ∞]  
  SFNode   [in,out]  metadata  NULL   [X3DMetadataObject]  
}
```

# Definition of Other Physical Properties

- **Temperature Node**

- The Temperature node specifies the unit for an object's or an environment's temperature
- It follows SI (International System of Units) specification and the basic unit is Kelvin (K)
- Located below an X3DPhysicalNode, and derived from an X3DShapeNode
- The unit field specifies a temperature unit
- The value field specifies a value for the temperature unit

```
Temperature : X3DPhysicalNode {  
  SFString [in,out]  unit      "K"  
                                ["0C"|"0F"|"K"|"0E"]  
  SFFloat  [in,out]  value     "1"    [0 , ∞]  
  SFNode   [in,out]  metadata  NULL   [X3DMetadataObject]  
}
```



# Definition of Other Physical Properties

- **Substance Node**

- The substance node specifies the unit for an object
- It follows SI (International System of Units) specification and the basic unit is mol
- Located below an X3DPhysicalNode, and derived from an X3DShapeNode
- The unit field specifies a substance unit
- The value field specifies a value for the substance unit

```
Substance : X3DPhysicalNode {  
  SFString [in,out]  unit      "MOL"  ["MOL"]  
  SFFloat  [in,out]  value     "1"    [0 , ∞]  
  SFNode   [in,out]  metadata  NULL   [X3DMetadataObject]  
}
```

# Definition of Other Physical Properties

- **Luminosity Node**

- The Luminosity node specifies the luminous intensity for an object
- It follows SI (International System of Units) specification and the basic unit is candela
- Located below an X3DPhysicalNode, and derived from an X3DShapeNode
- The unit field specifies a luminosity unit
- The value field specifies a value for the luminosity unit

```
Luminosity : X3DPhysicalNode {  
  SFString [in,out]  unit      "CD"      ["CD"|"LM"|"LUX"]  
  ]SFFloat [in,out]  value     "1"      [0 , ∞]  
  SFNode [in,out]   metadata  NULL     [X3DMetadataObject]  
}
```

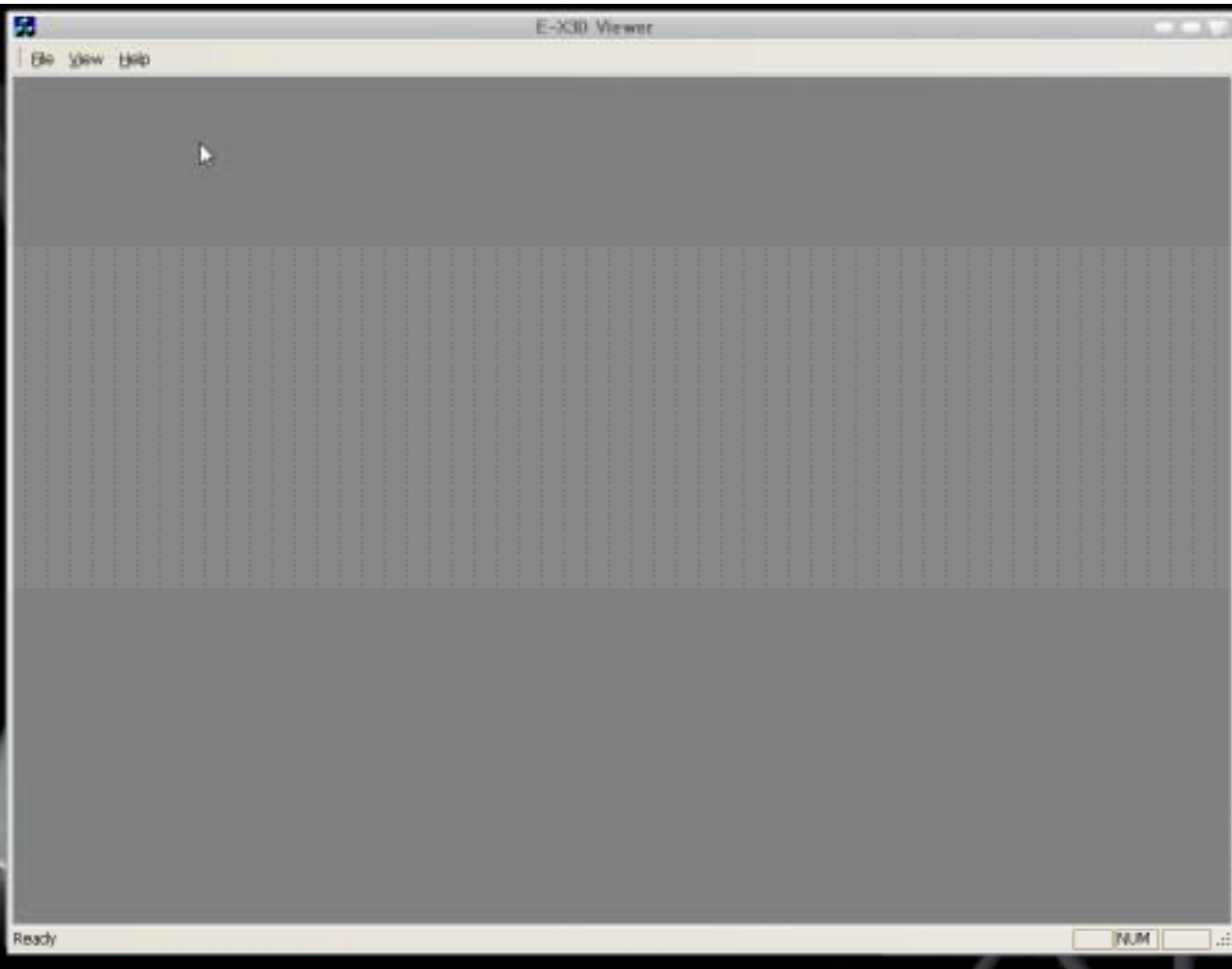
# Definition of Other Physical Properties

- **SoundPressure Node**

- The SoundPressure node specifies the sound pressure for an object.
- It follows SI (International System of Units) specification and the basic unit is decibel (dB).
- Located below an X3DPhysicalNode, and derived from an X3DShapeNode
- The unit field specifies a sound pressure unit.
- The value field specifies a value for the sound pressure unit.

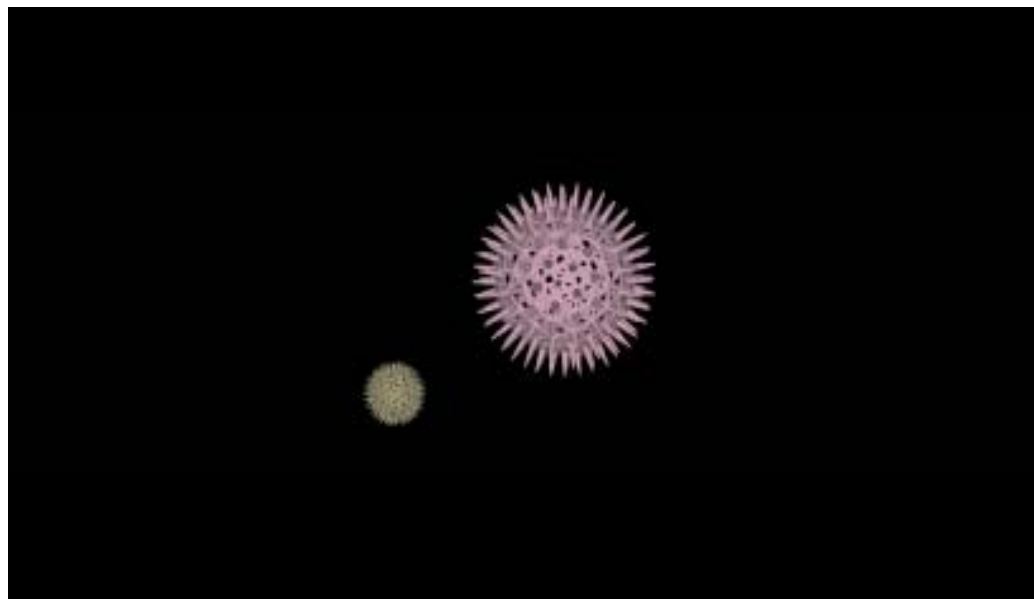
```
SoundPressure : X3DPhysicalNode {  
  SFString [in,out]  unit      "DB"    ["DB"|"PA"]  
  SFFloat  [in,out]  value     "1"     [0 , ∞]  
  SFNode   [in,out]  metadata  NULL   [X3DMetadataObject]  
}
```

# Implementation Results



1. Cup → Millimeter  
( $10^{-3}$ )
2. Table → Centimeter  
( $10^{-2}$ )
3. Chair → Centimeter  
( $10^{-2}$ )

# Implementation Results



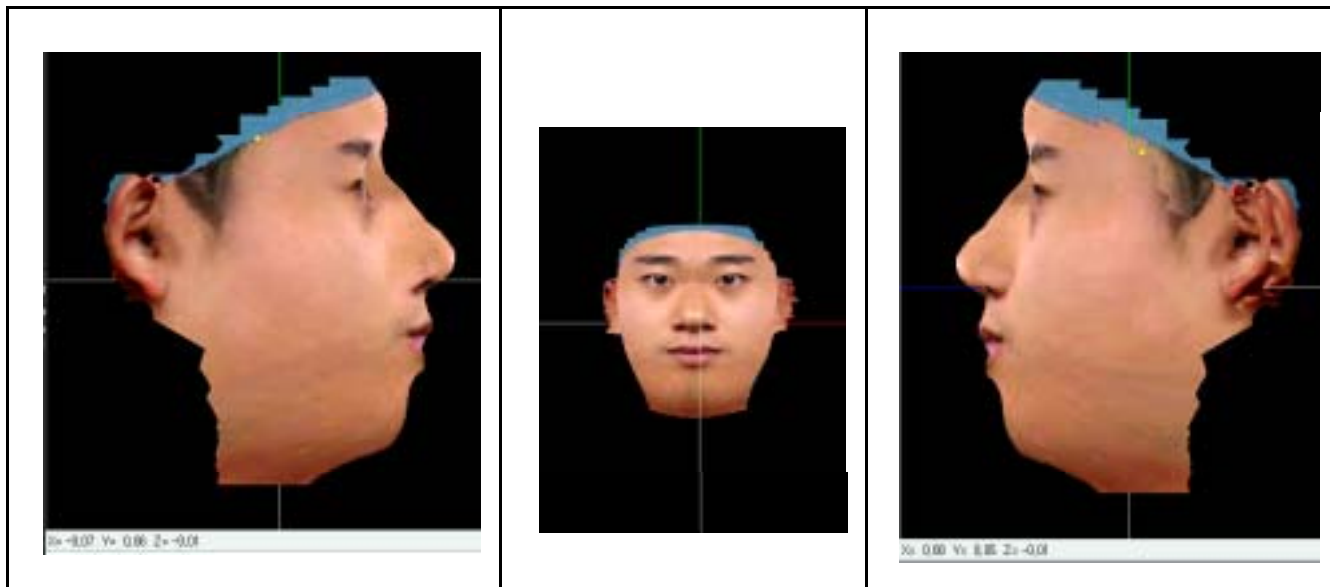
```
<Length unit = "MICRO" basis = "1" numeral = "DEC"/>  
<Transform scale = "10 10 10">
```

```
<Length unit = "MILLI" basis = "1" numeral = "DEC"/>  
<Transform scale = "0.1 0.1 0.1">
```

➤ Microorganisms specified with different units

➤ 10  $\mu\text{m}$  and 0.1 mm

# Implementation Results



A Facial model defined in millimeter

- In order to represent precise measurement values for real facial models.
- The standard unit for a human face and body is millimeter.

<Physical>  
<Length unit = "MILLI" basis = "1" numeral = "DEC">  
</Physical>

**Thank you.**