Health Information Modeling and Representation for VR Smart Cities

Web3D Conference 2020 (Online)

November 9-13, 2020

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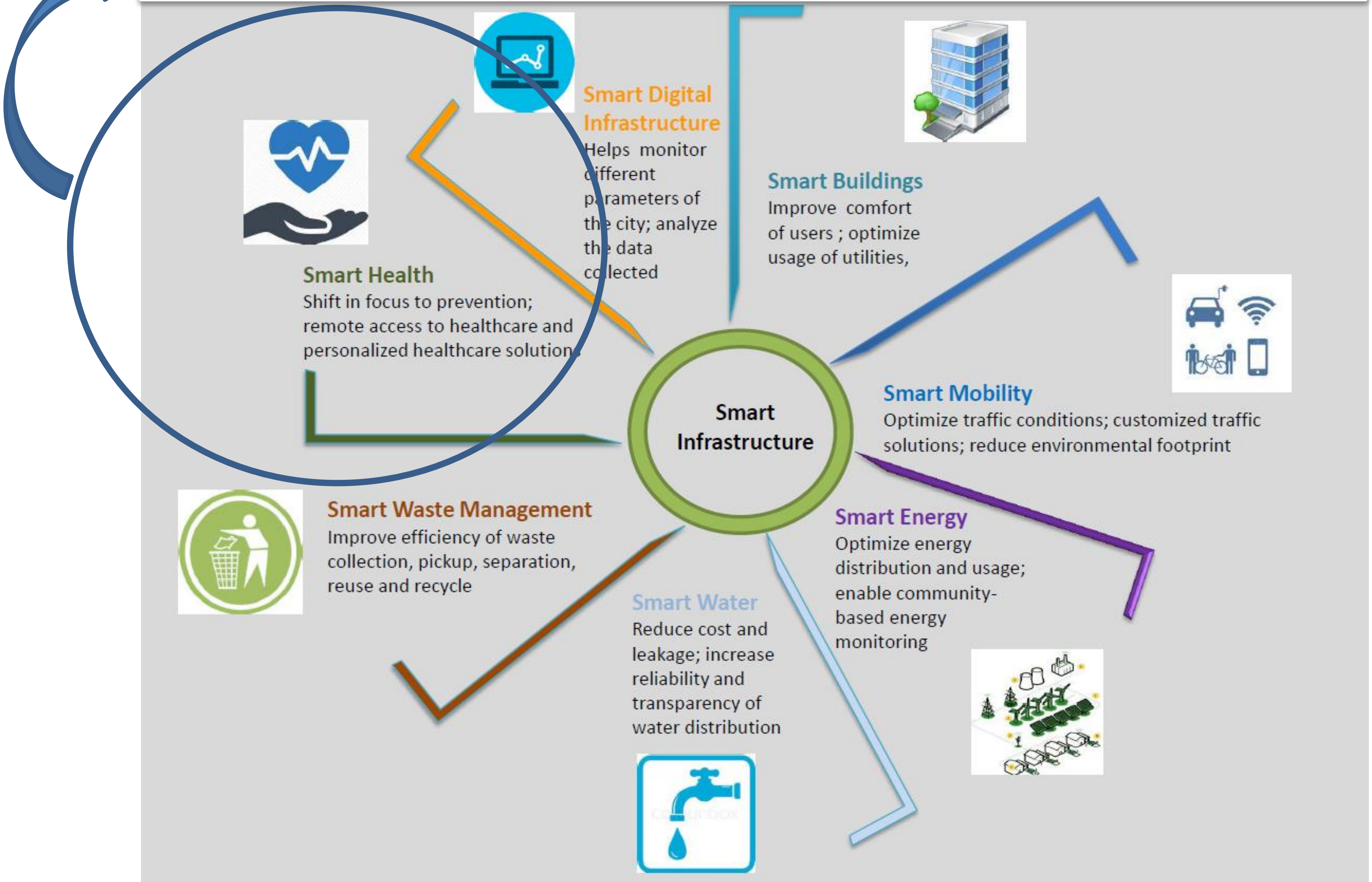
Definition of Smart City

- "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental, as well as cultural aspects"

  ITU study group on SSC

Smart health care information and 3D virtual environments



Smart Digital Infrastructure
Helps monitor different parameters of the city; analyze the data collected

Smart Buildings
Improve comfort of users ; optimize usage of utilities,

Smart Health
Shift in focus to prevention; remote access to healthcare and personalized healthcare solutions

Smart Infrastructure

Smart Mobility
Optimize traffic conditions; customized traffic solutions; reduce environmental footprint

Smart Waste Management
Improve efficiency of waste collection, pickup, separation, reuse and recycle

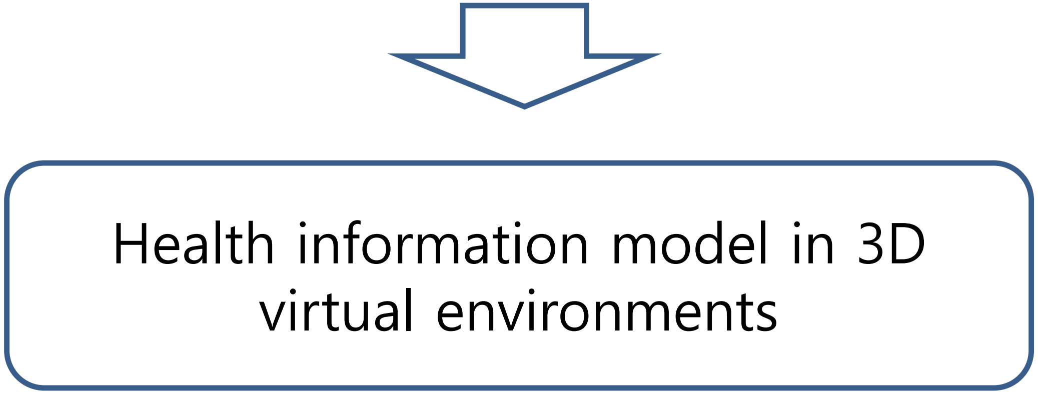
Smart Energy
Optimize energy distribution and usage; enable community-based energy monitoring

Smart Water
Reduce cost and leakage; increase reliability and transparency of water distribution

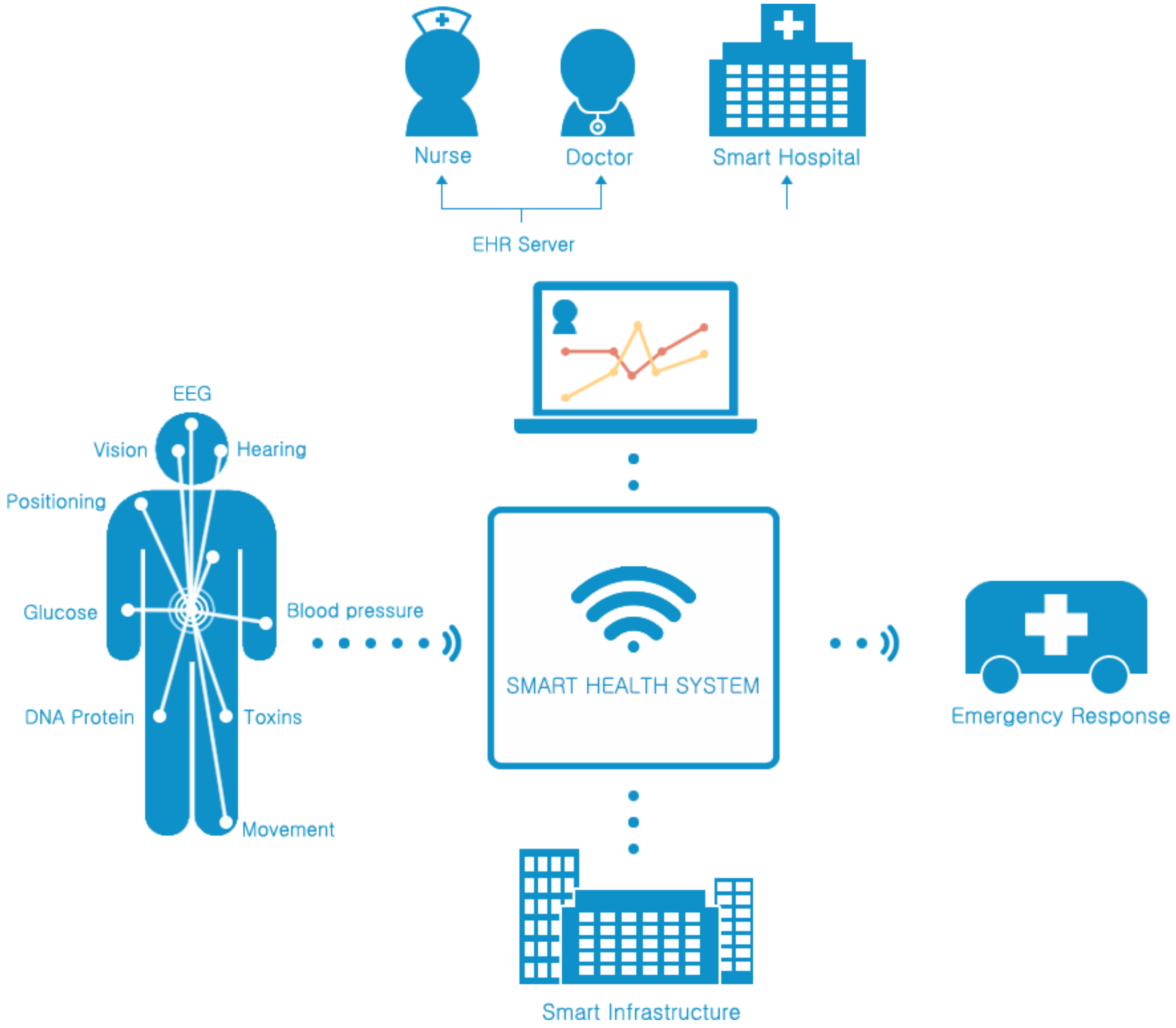
UNCTAD (United Nations Commission on Science and Technology for Development), 2016

Smart Health

- Remote access to health information
- Personalized health information monitoring



Health information model in 3D virtual environments



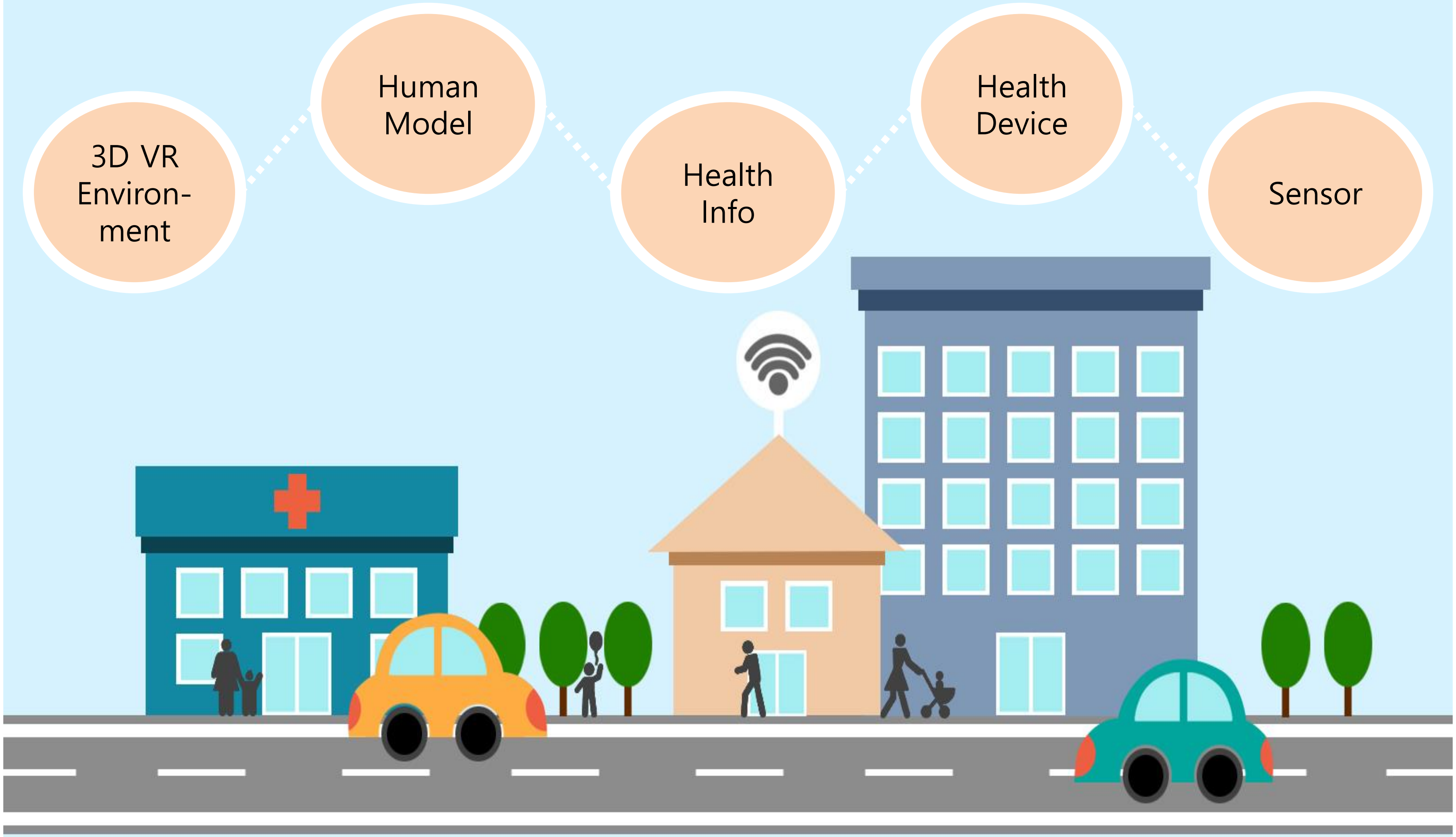
Concept of smart city health system

Health Information Services

- Health Information Services are responsible for the collection, processing, storage, retrieval, and dissemination of patient information, in both paper and electronic format, to facilitate an optimal level of direct and indirect patient care, and for research, quality improvement, hospital, Local Health District and Department of Health management and decision-making purposes (https://www.nslhd.health.nsw.gov.au/Services/Directory/Pages/HIS.aspx)

Visualization for digital health information systems

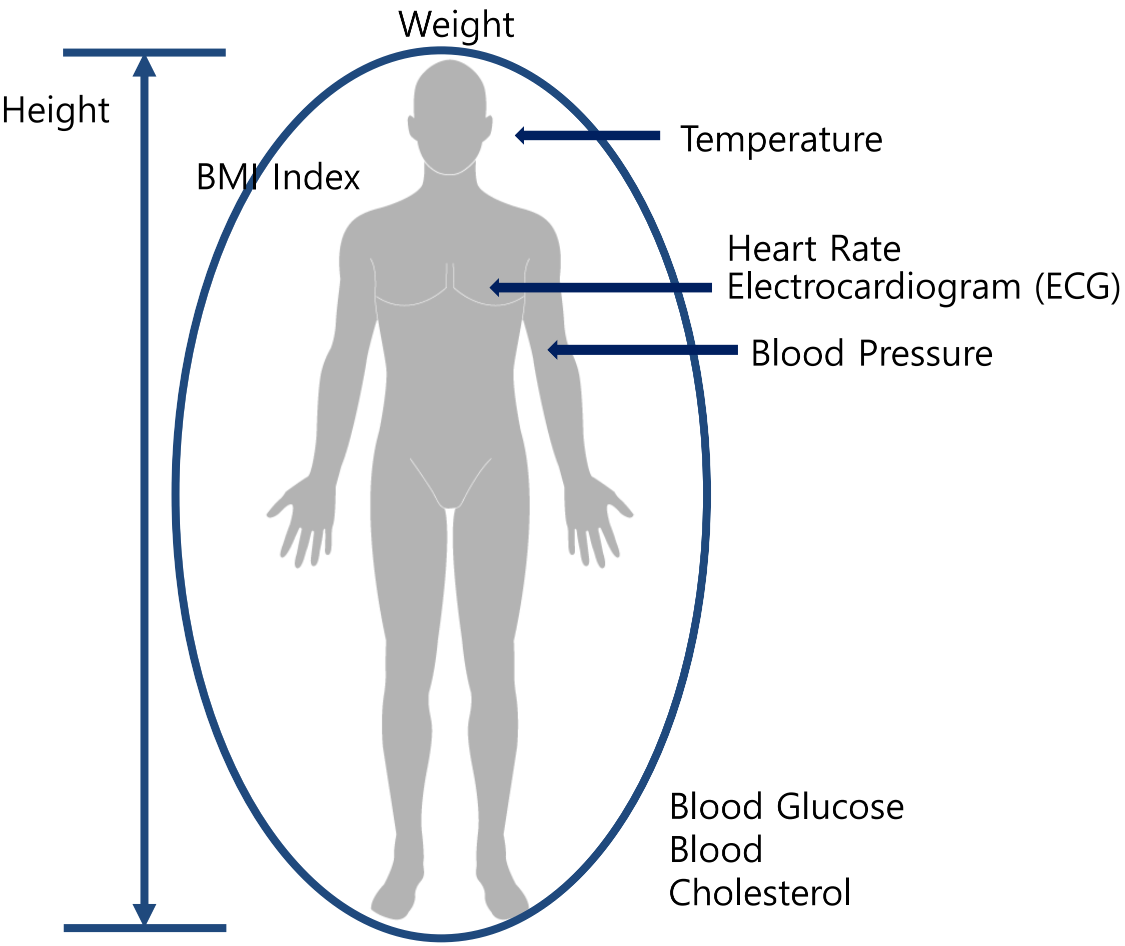
USE CASE
- Health Information Systems in a 3D Smart City



Health Information Sensors

- Health information sensors are of various types and facilitate the detection of physiological signals, human activities, and environment conditions. Some types of sensors are embedded in wearables such as digital watches or clothing. Sensors monitor health conditions and safety of humans. They also provide for earlier detection of impending disability.

Physiological sensor types



Height

Weight

BMI Index

Temperature

Heart Rate

Electrocardiogram (ECG)

Blood Pressure

Blood Glucose

Blood Cholesterol

Health Care Information Factors (1)

- Blood Glucose
  mg/dL, the concentration of blood sugar in the blood
- Blood Pressure
  mm/Hg, the cyclic pressure exerted by blood against the walls of blood vessels
- Electrocardiogram (ECG)
  the electrical potential differences between electrodes placed on a person’s body
- Heart Rate
  beats/min, the number of heartbeats per unit of time

Health Care Information Factors (2)

- Body Temperature
  ℃, the typical temperature range found in humans.
- Height
  cm/feet, the distance from the bottom of the feet to the top of the head in a human body.
- Weight
  kg/lb, weight without items.
- BMI index
  kg/m^2, the body mass divided by the square of the body height.
- Blood Cholesterol
  mg/dl, levels of any or all lipids or lipoproteins in the blood.

A Data Model for 3D VR Health Information Systems (1)

- Representation of 3D VR environments
- Representation of 3D human models and animation
- Representation of health device sensor information
- Representation of human health information

A Data Model for 3D VR Health Information Systems (2)

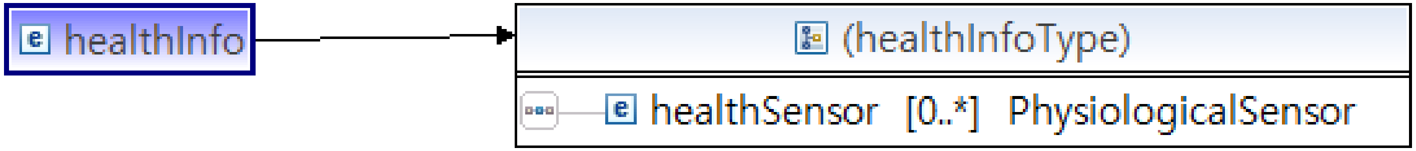
- Representation of 3D VR environments
  - 3D data model
- Representation of 3D human models and animation
  - 3D human model
- Representation of health device sensor information
  - Sensor representation in MAR
- Representation of human health information in 3D VR environments

Systems Integration of Human Health Information and 3D Virtual Environments

Definition of XML Schema for Health Sensor Information

Root Element

- healthInfo
  - consists of *healthSensor* elements of *PhysiologicalSensor* type

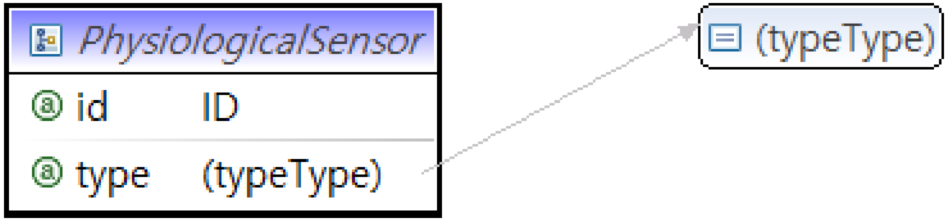


  - XML Schema Definition

```
<element name="healthInfo">
  <complexType>
     <sequence>
        <element name="healthSensor" type="h:PhysiologicalSensor"
               minOccurs="0" maxOccurs="unbounded" />
     </sequence>
  </complexType>
</element>
```

Physiological Sensor Type

- PhysiologicalSensor
  - An abstract super-type of all physiological sensor types, which includes:
    - id: sensor identification
    - type: sensor type which has one of nine values:
      - BloodGlucose, BloodPressure, ECG, HeartRate, BodyTemperature, Height, Weight, BMI, BloodCholesterol
  - Physical properties should be defined for each sensor type



Physiological Sensor Type

– XML Schema Definition

```
<complexType name="PhysiologicalSensor" abstract="true">
    <attribute name="id" type="ID" />
    <attribute name="type">
        <simpleType>
            <restriction base="string">
                <enumeration value="BloodGlucose" />
                <enumeration value="BloodPressure" />
                <enumeration value="ECG" />
                <enumeration value="HeartRate" />
                <enumeration value="BodyTemperature" />
                <enumeration value="Height" />
                <enumeration value="Weight" />
                <enumeration value="BMI" />
                <enumeration value="BloodCholesterol" />
            </restriction>
        </simpleType>
    </attribute>
</complexType>
```

Blood Glucose Sensor Type

```
<complexType name="BloodGlucoseSensor">
  <complexContent>
    <extension base="h:PhysiologicalSensor">
      <sequence>
        <element name="fastingPlasmaGlucose" minOccurs="0">
          <complexType>
            <simpleContent>
              <restriction base="h:FloatWithUnit">
                 <attribute name="unit" type="string" default="mg/dL"/>
              </restriction>
            </simpleContent>
          </complexType>
        </element>
        <element name="twoHourPostloadPlasmaGlucose" minOccurs="0">
          <complexType>
              ... same as the above element ...
          </complexType>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
```

Example XML Document

- Example Health Info Document

```xml
<healthInfo xmlns="http://www.example.org/healthSensor"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.example.org/healthSensor HealthSensor.xsd ">

  <healthSensor xsi:type="BloodGlucoseSensor" id="sensor01">
      <fastingPlasmaGlucose unit="mg/dL">20.2</fastingPlasmaGlucose>
      <twoHourPostloadPlasmaGlucose>20.2</twoHourPostloadPlasmaGlucose>
         <!-- default unit="mg/dL" -->
  </healthSensor>

  <healthSensor xsi:type="BloodPressureSensor" id="sensor02">
      <systolic unit="mm/Hg">20.2</systolic>
      <diastolic>20.2</diastolic>        <!-- default unit="mm/Hg" -->
  </healthSensor>

  <healthSensor xsi:type="ECGSensor" id="sensor03">
      <waveform></waveform>
  </healthSensor>
```

Example XML Document

- Example Health Info Document (cont'd)

```
<healthSensor xsi:type="HeartRateSensor" id="sensor04">
    <heartbeats unit="beats/m">120</heartbeats>
</healthSensor>

<healthSensor xsi:type="BodyTemperatureSensor" id="sensor05">
    <temperature unit="˚C">20.2</temperature>
</healthSensor>

<healthSensor xsi:type="HeightSensor" id="sensor06">
    <height unit="cm">20.2</height>
</healthSensor>

<healthSensor xsi:type="WeightSensor" id="sensor07">
    <weight unit="kg">20.2</weight>
</healthSensor>
```

Example XML Document

– Example Health Info Document (cont’d)

```
  <healthSensor xsi:type="BMISensor" id="sensor08">
      <bmi unit="kg/m^2">20.2</bmi>
  </healthSensor>

  <healthSensor xsi:type="BloodCholesterolSensor" id="sensor09">
      <LDL unit="mg/dL">20.2</LDL>
      <HDL>20.2</HDL>                         <!-- default unit="mg/dL" -->
      <neutraFat>20.2</neutraFat>             <!-- default unit="mg/dL" -->
  </healthSensor>

</healthInfo>
```

Implementation of a VR based Health Information System

(X3D, HAnim, Unity)

Android Sensors

- Motion sensor
  - Accelerometer, gravity sensor, gyroscope, rotational vector sensor
- Environment sensor
  - Temperature, barometer, photometer, thermometer
- Position sensor
  - Orientation sensor, magnetometer

Android Sensor Types

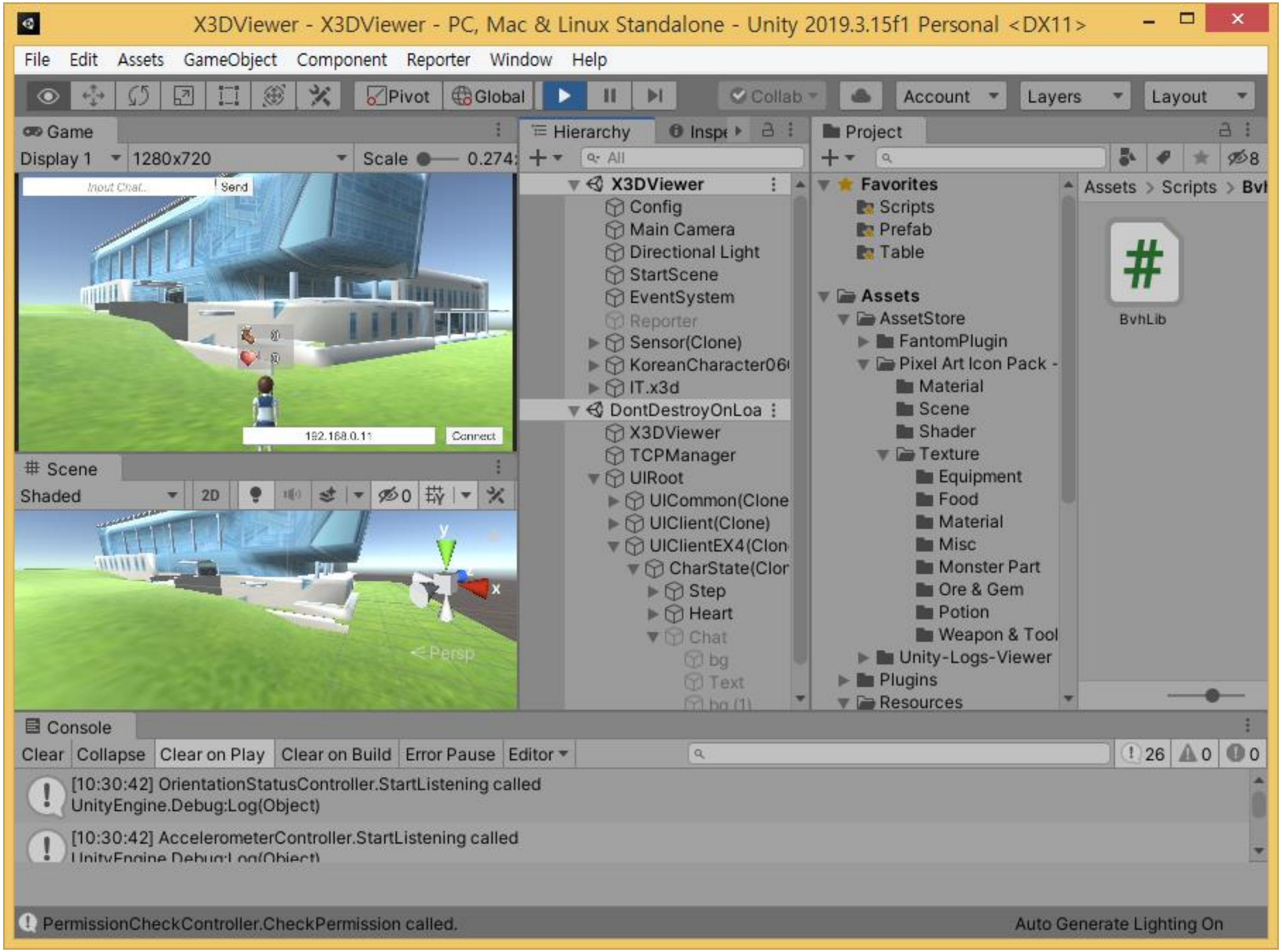
Type	Sensor	Value
int	TYPE_ACCELEROMETER	1
int	TYPE_ALL	-1
int	TYPE_AMBIENT_TEMPERATURE	13
int	TYPE_GAME_ROTATION_VECTOR	15
int	TYPE_GEOMAGNETIC_ROTATION_VECTOR	20
int	TYPE_GRAVITY	9
int	TYPE_GYROSCOPE	4
int	TYPE_LIGHT	5
int	TYPE_MAGNETIC_FIELD	2

Type	Sensor	Value
int	TYPE_MOTION_DETECT	30
int	TYPE_ORIENTATION	3
int	TYPE_PRESSURE	6
int	TYPE_PROXIMITY	8
int	TYPE_RELATIVE_HUMANITY	12
int	TYPE_ROTATION_VECTOR	11
int	TYPE_SIGNIFICANT_MOTION	17
int	TYPE_STEP_COUNTER	19
int	TYPE_STEP_DETECTOR	18
int	TYPE_TEMPERATURE	7

Android Sensor Methods

Type	Method	Description
int	getType( )	Type of sensor
String	getName( )	Name of sensor
float	getPower( )	Power usage (mA)
float	getResolution( )	Resolution
float	getMaximumRange( )	Maximum range of measurement
String	getVendor( )	Vendor name
int	getVersion( )	Version
int	getMinDelay( )	Minimum delay between two events (μsec)
String	toString( )	Info of sensor

A Health Information System Using Sensors

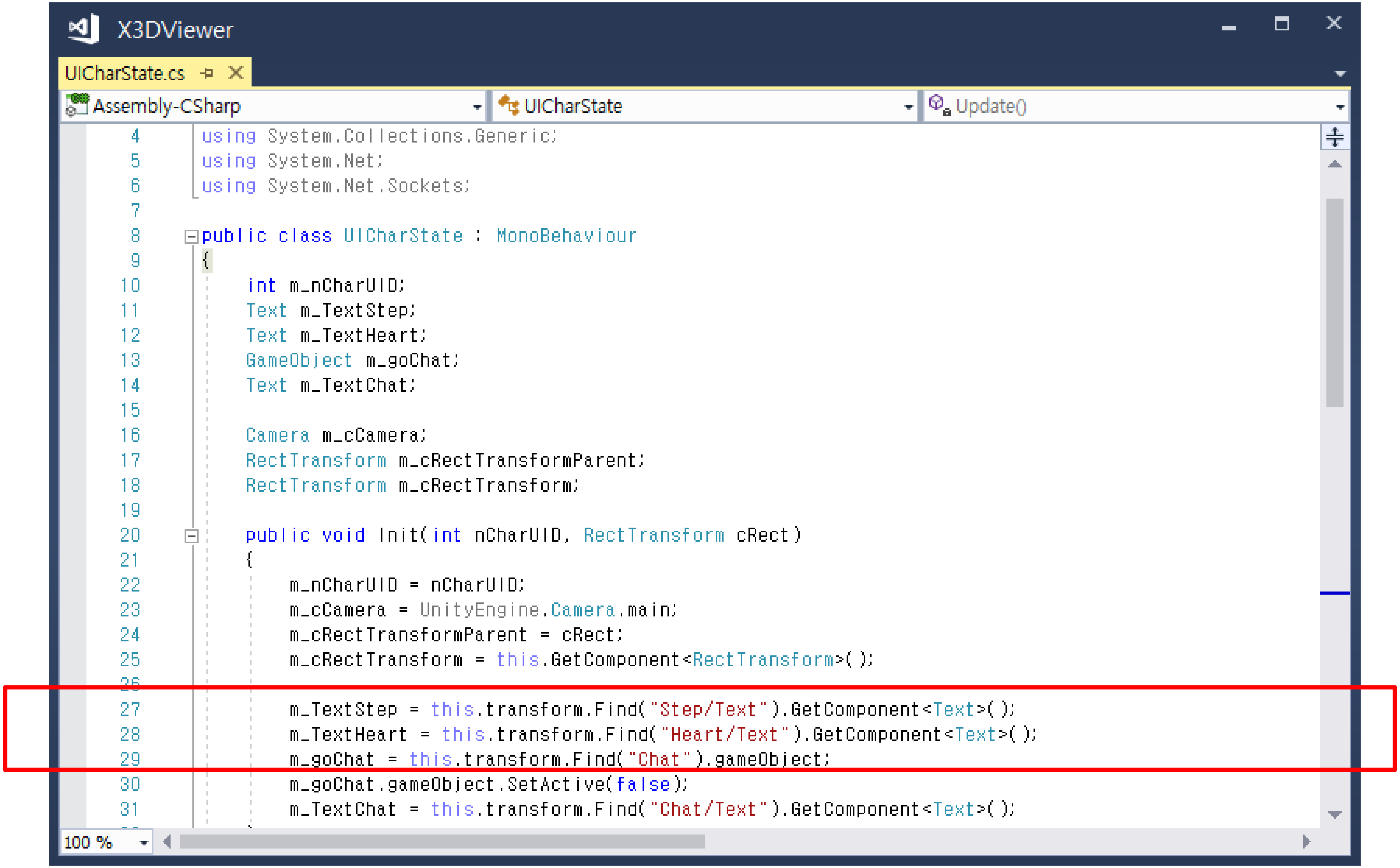


```
[10:30:42] OrientationStatusController.StartListening called
UnityEngine.Debug:Log(Object)
[10:30:42] AccelerometerController.StartListening called
UnityEngine.Debug:Log(Object)
```

PermissionCheckController.CheckPermission called.

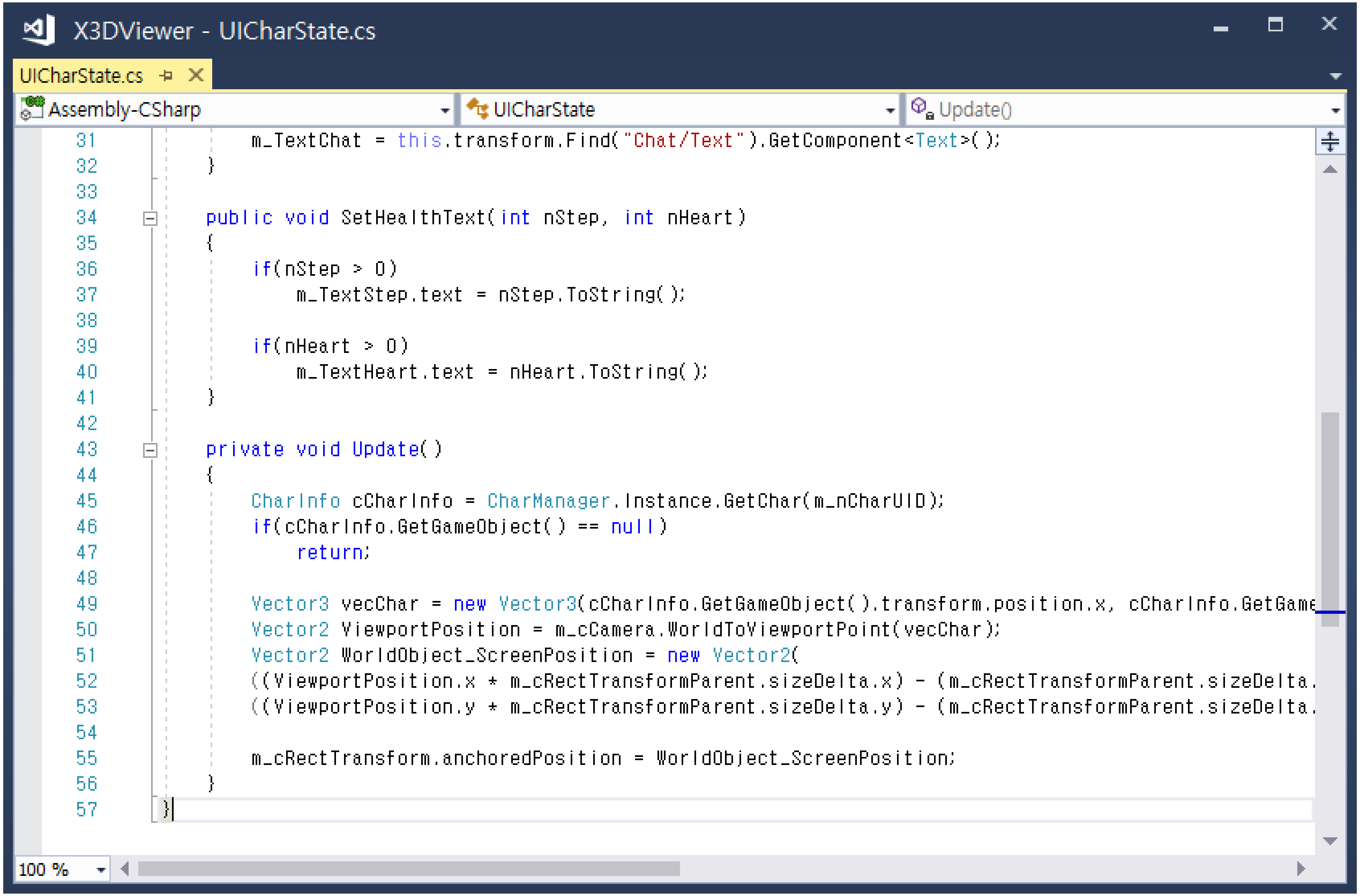
Auto Generate Lighting On

Health UI Scripts in an X3D Viewer



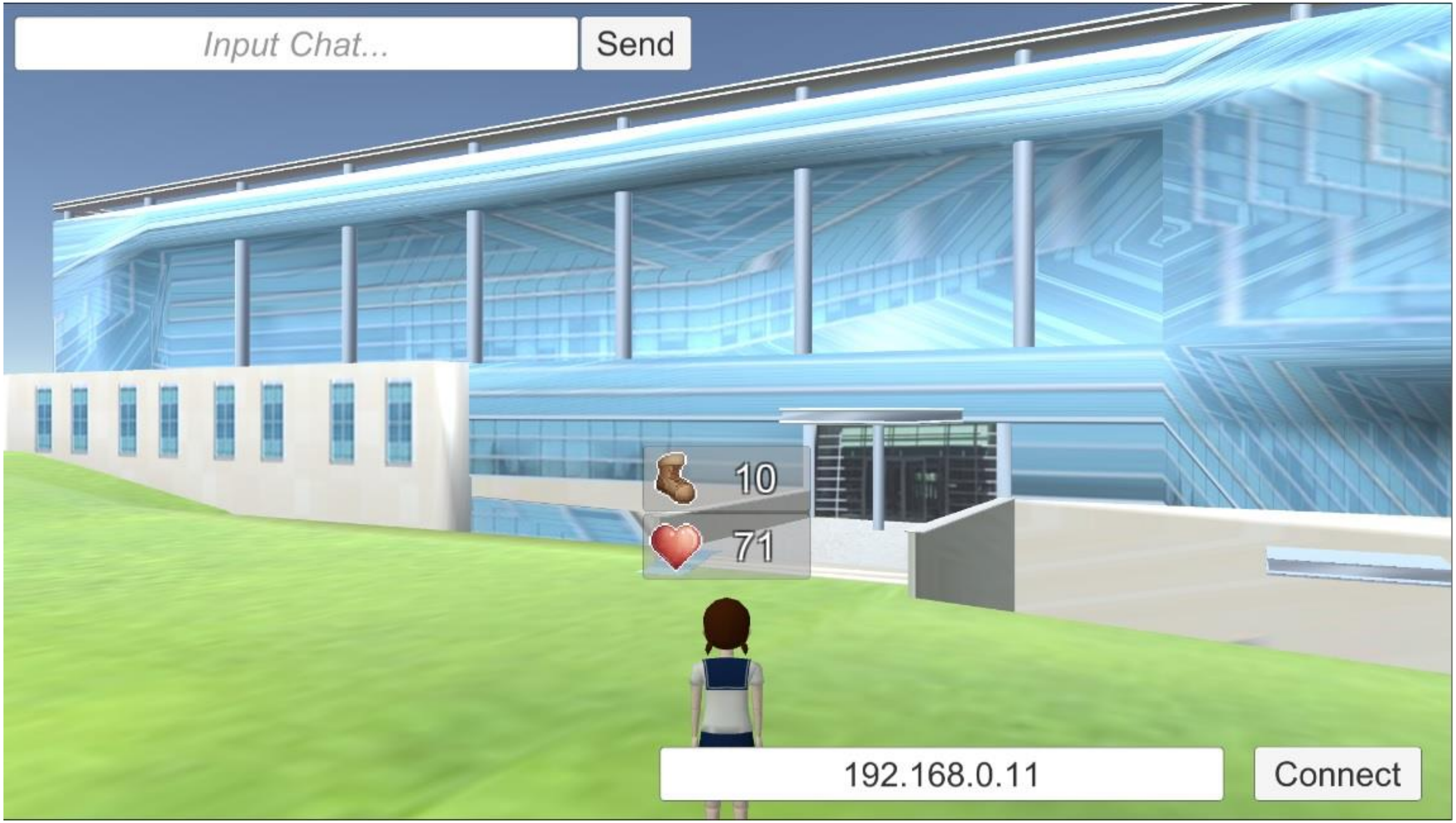
```
using System.Collections.Generic;
using System.Net;
using System.Net.Sockets;

public class UICharState : MonoBehaviour
{
    int m_nCharUID;
    Text m_TextStep;
    Text m_TextHeart;
    GameObject m_goChat;
    Text m_TextChat;

    Camera m_cCamera;
    RectTransform m_cRectTransformParent;
    RectTransform m_cRectTransform;

    public void Init(int nCharUID, RectTransform cRect)
    {
        m_nCharUID = nCharUID;
        m_cCamera = UnityEngine.Camera.main;
        m_cRectTransformParent = cRect;
        m_cRectTransform = this.GetComponent<RectTransform>( );

        m_TextStep = this.transform.Find("Step/Text").GetComponent<Text>( );
        m_TextHeart = this.transform.Find("Heart/Text").GetComponent<Text>( );
        m_goChat = this.transform.Find("Chat").gameObject;
        m_goChat.gameObject.SetActive(false);
        m_TextChat = this.transform.Find("Chat/Text").GetComponent<Text>( );
```

Coordinates Synchronization of Avatar Location

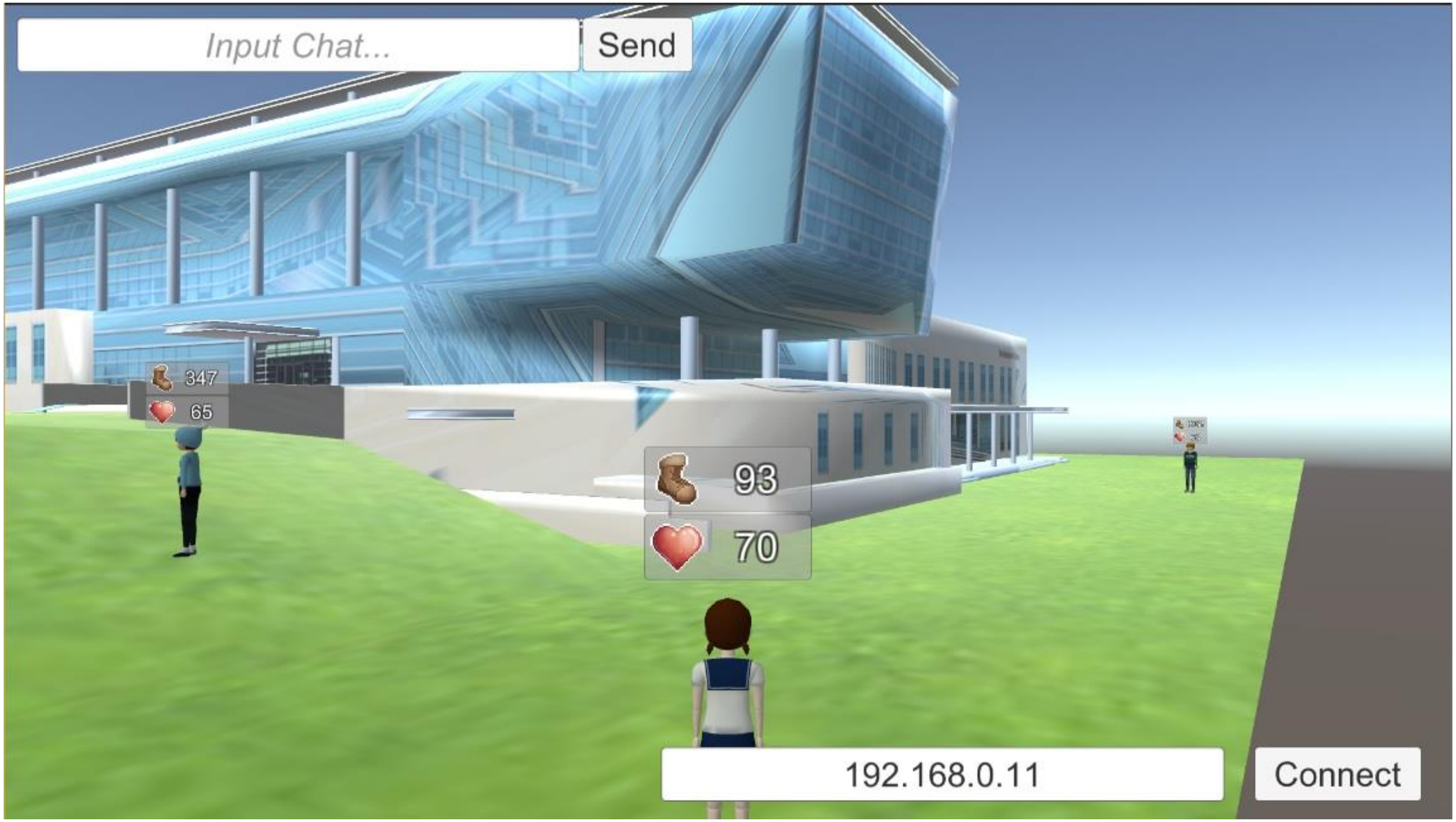


```
        m_TextChat = this.transform.Find("Chat/Text").GetComponent<Text>();
    }

    public void SetHealthText(int nStep, int nHeart)
    {
        if(nStep > 0)
            m_TextStep.text = nStep.ToString();

        if(nHeart > 0)
            m_TextHeart.text = nHeart.ToString();
    }

    private void Update()
    {
        CharInfo cCharInfo = CharManager.Instance.GetChar(m_nCharUID);
        if(cCharInfo.GetGameObject() == null)
            return;

        Vector3 vecChar = new Vector3(cCharInfo.GetGameObject().transform.position.x, cCharInfo.GetGame
        Vector2 ViewportPosition = m_cCamera.WorldToViewportPoint(vecChar);
        Vector2 WorldObject_ScreenPosition = new Vector2(
        ((ViewportPosition.x * m_cRectTransformParent.sizeDelta.x) - (m_cRectTransformParent.sizeDelta.
        ((ViewportPosition.y * m_cRectTransformParent.sizeDelta.y) - (m_cRectTransformParent.sizeDelta.

        m_cRectTransform.anchoredPosition = WorldObject_ScreenPosition;
    }
}
```

Representation of Health Information Using GPS, Gyro, Heart Rate Sensors

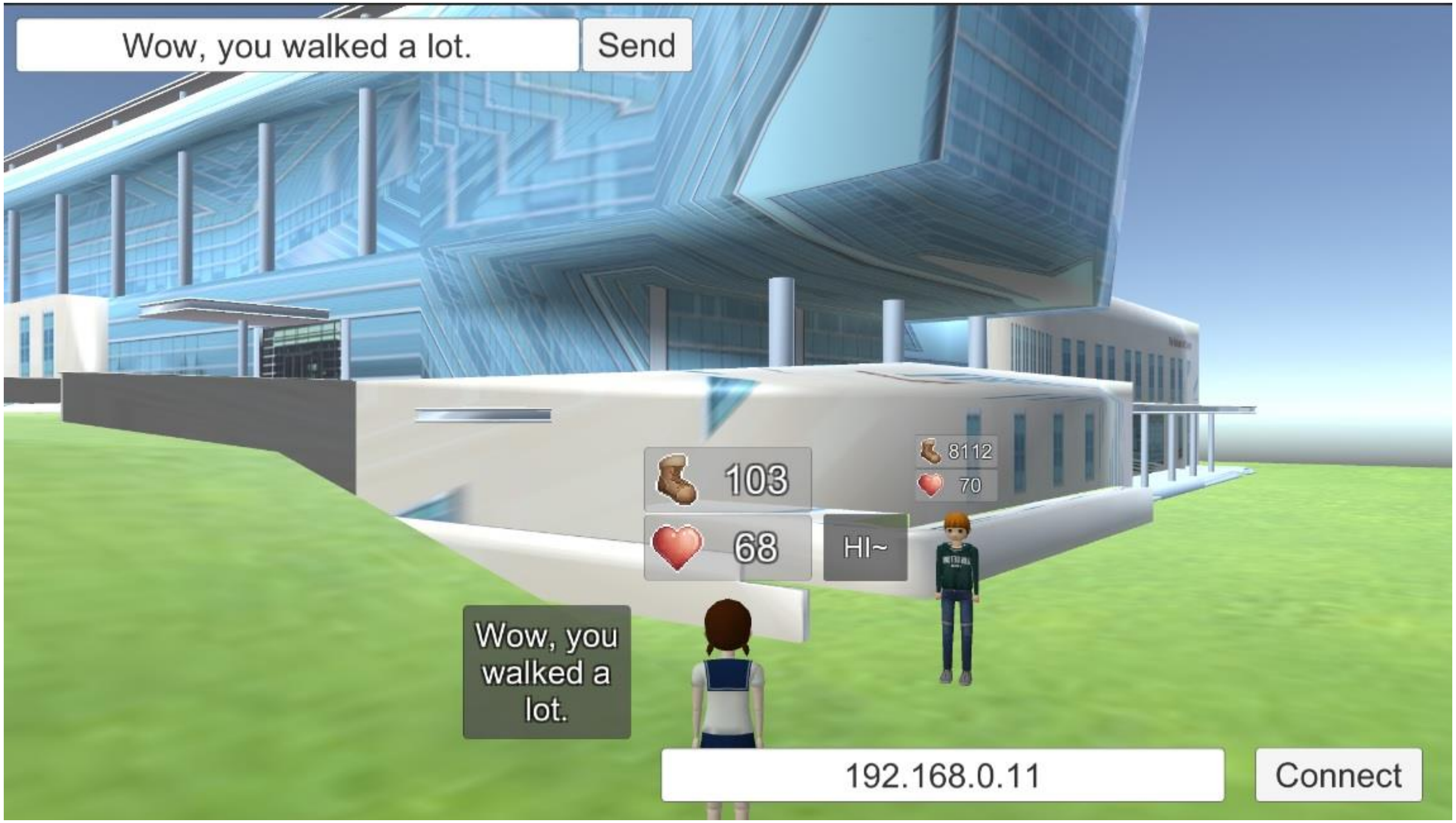


Synchronization and Communication between People



192.168.0.11

Management of Health Information



Conclusions

- The representation model for VR based health information
  - Representation of health information in 3D virtual environment for smart city
  - Definition of health information using XML
- Implementation of a health information system
- Management of human health information