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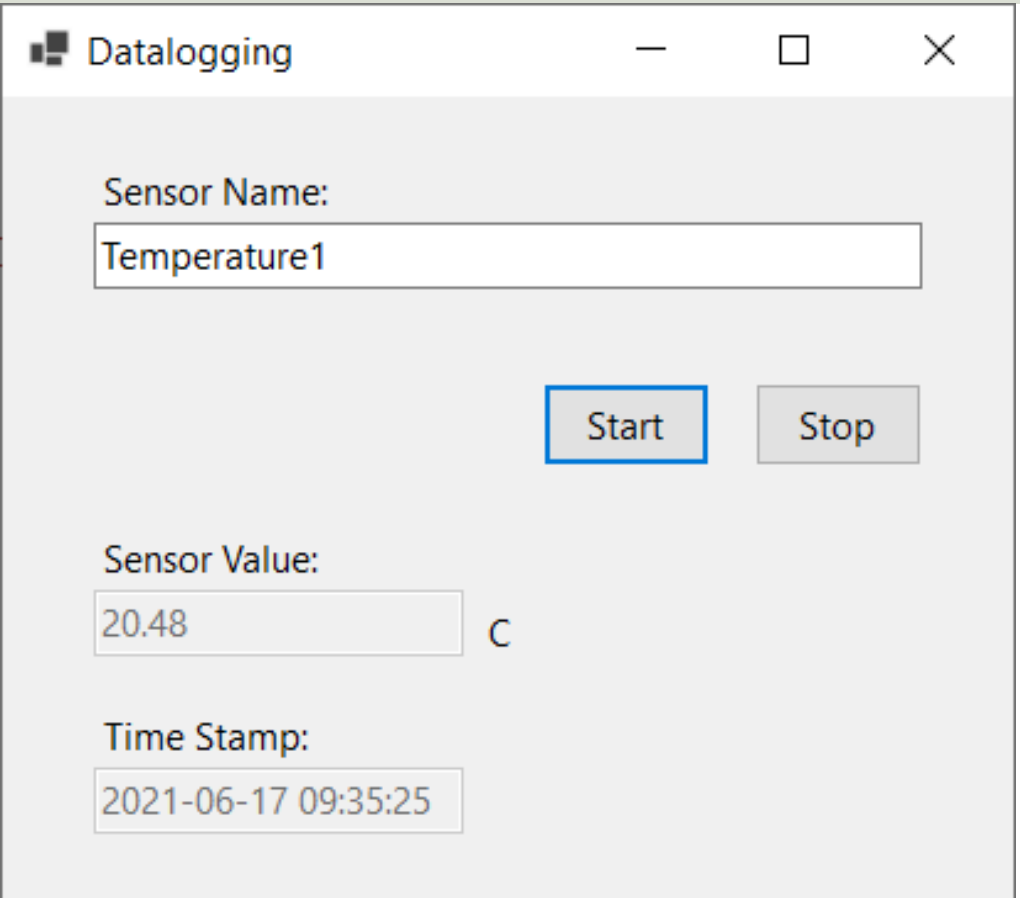
Datalogging using SQL Server with C#

Windows Forms App

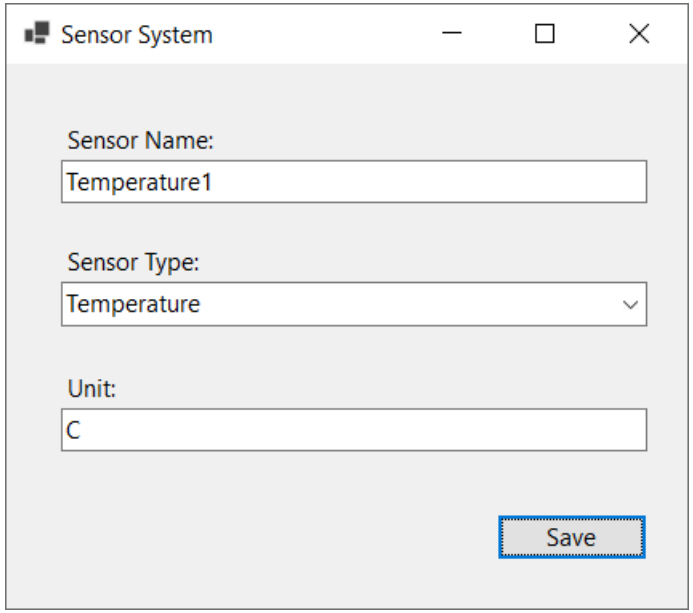
Hans-Petter Halvorsen

Goal



- Here you see a screenshot of the C# Windows Forms App we are going to create from scratch.
- We will not use a real Sensor, just create a dummy Simulator.
- We will use the Random Generator in C# to generate random data to simulate the Sensor.
- The Data from the Sensor will be logged into a SQL Server Database

Sensor System with Datalogging



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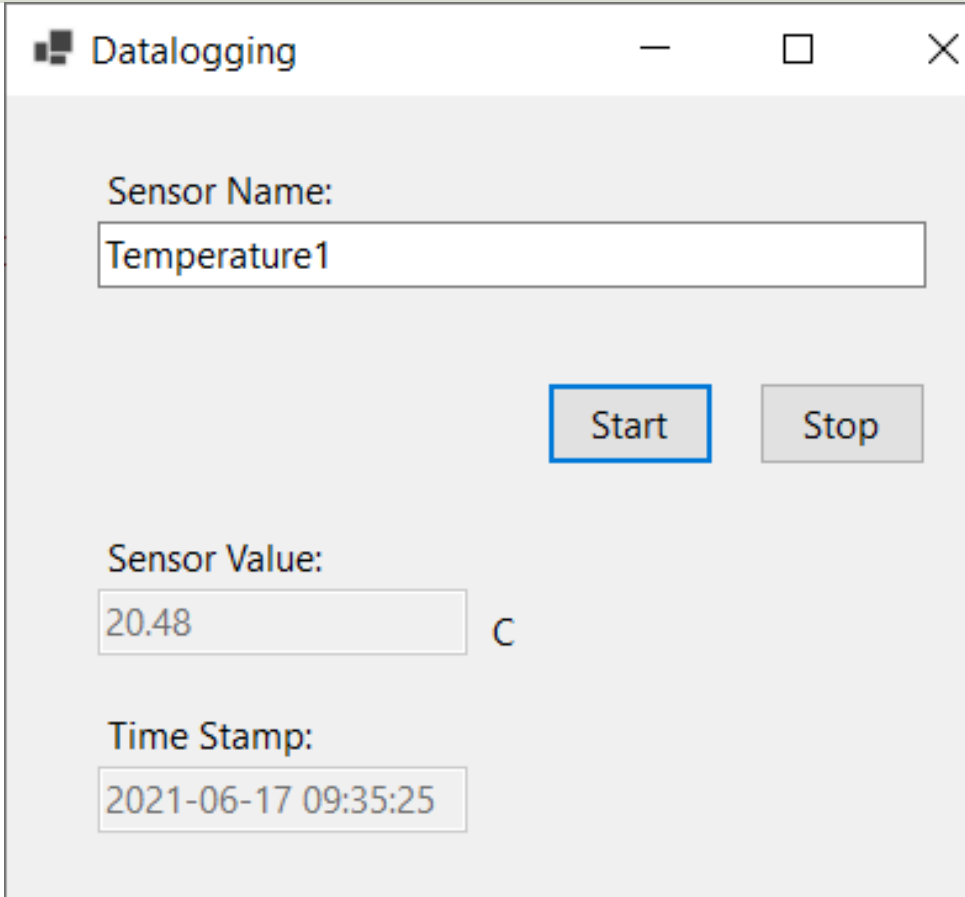
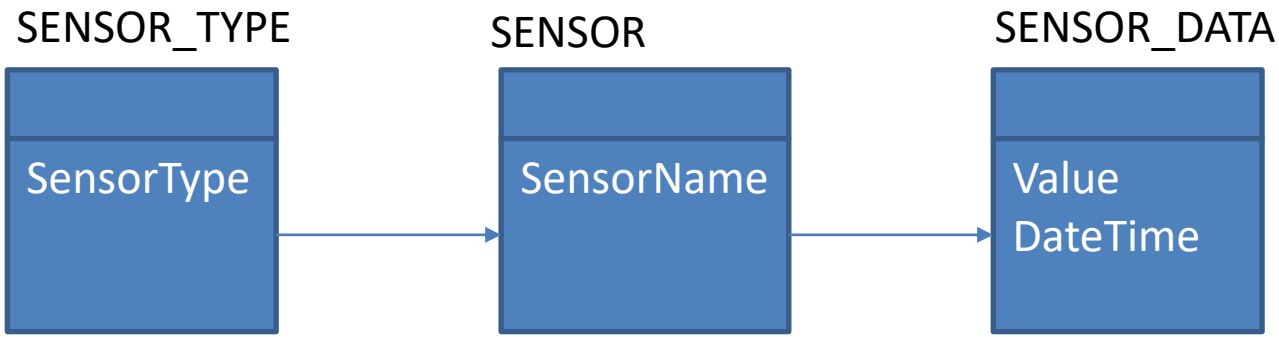


SQL Server with C# Windows Forms App

https://youtu.be/rXugzELsQl0

Sensor System with Datalogging

Database Structure:



Contents

- SQL Server
- ADO.NET
- C# WinForms Examples
- Structured Query Language (SQL)
- Saving Data
- Retrieving Data
- Timer

Audience

- This Tutorial is made for rookies making their first basic C# Windows Forms Database Application
- You don’t need any experience in either Visual Studio or C#
- No skills in Automation or Control System is necessary

Background

- This Tutorial follows the Tutorial “SQL Server with C# Windows Forms App”
- YouTube Video: https://youtu.be/rXugzELsQl0
- It is recommended that you watch this first, but it is not absolute necessary

C# Examples

Note!

- The examples provided can be considered as a “proof of concept”
- The sample code is very simplified for clarity and doesn't necessarily represent best practices.

SQL Server

- SQL Server Express
  - Free version of SQL Server that has all we need for the exercises in this Tutorial
- SQL Server Express consist of 2 parts (separate installation packages):
  - SQL Server Express
  - SQL Server Management Studio (SSMS) – This software can be used to create Databases, create Tables, Insert/Retrieve or Modify Data, etc.
- SQL Server Express Installation: https://youtu.be/hhhggAlUYo8

ADO.NET

- ADO.NET is the core data access technology for .NET languages.
- System.Data.SqlClient (or the newer Micrsoft.Data.SqlClient) is the provider or namespace you typically use to connect to an SQL Server

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Sensor System

Windows Forms App #1

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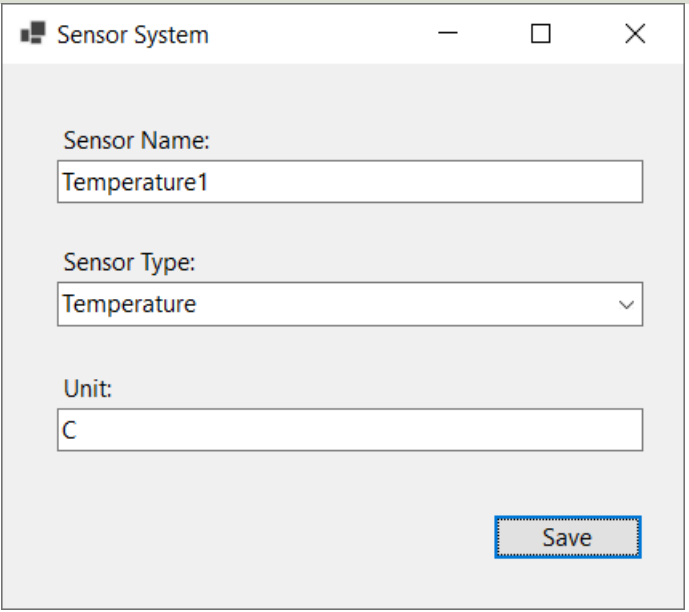
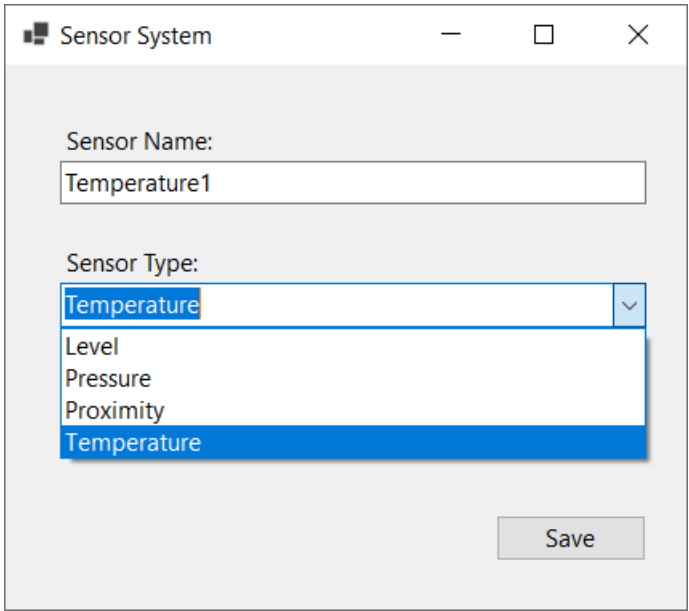
Sensor System Windows Forms App



The different Sensor Types will no be retrieved from the SQL Server Database



Database

```
CREATE TABLE SENSOR_TYPE
(
SensorTypeId int  PRIMARY KEY  IDENTITY (1,1),
SensorType varchar(50) NOT NULL UNIQUE
)
GO

CREATE TABLE SENSOR
(
SensorId int PRIMARY KEY  IDENTITY (1,1),
SensorName varchar(50)  UNIQUE NOT NULL,
SensorTypeId int NOT NULL FOREIGN KEY REFERENCES SENSOR_TYPE(SensorTypeId),
Unit varchar(50) NULL,
)
GO

CREATE TABLE SENSOR_DATA
(
SensorDataId int PRIMARY KEY  IDENTITY (1,1),
SensorId int NOT NULL FOREIGN KEY REFERENCES SENSOR(SensorId),
SensorValue float NOT NULL,
SensorDateTime datetime NOT NULL
)
GO
```

Stored Procedure - SaveSensor

```
IF EXISTS (SELECT name
   FROM   sysobjects
   WHERE  name = 'SaveSensor'
   AND   type = 'P')
DROP PROCEDURE SaveSensor
GO

CREATE PROCEDURE SaveSensor
@SensorName varchar(50),
@SensorType varchar(50),
@Unit varchar(50)
AS

DECLARE
@SensorTypeId int

SELECT @SensorTypeId=SensorTypeId FROM SENSOR_TYPE WHERE SensorType=@SensorType

INSERT INTO SENSOR (SensorName, SensorTypeId, Unit) VALUES (@SensorName, @SensorTypeId, @Unit)

GO
```

Test Data

We insert the folllowing Data using the SQL Server Management Studio:

SENSOR_TYPE:

```
insert into SENSOR_TYPE (SensorType) values ('Temperature')
insert into SENSOR_TYPE (SensorType) values ('Pressure')
insert into SENSOR_TYPE (SensorType) values ('Level')
insert into SENSOR_TYPE (SensorType) values ('Proximity ')
```

SensorType.cs

```
using System;
using System.Collections.Generic;
using Microsoft.Data.SqlClient;
using System.Configuration;

namespace SensorSystem.Classes
{
    class SensorType
    {
        string connectionString = ConfigurationManager.ConnectionStrings["DatabaseConnectionString"].ConnectionString;
        public int SensorTypeId { get; set; }
        public string SensorTypeName { get; set; }

        public List<SensorType> GetSensorTypes()
        {
            List<SensorType> sensorTypeList = new List<SensorType>();

            SqlConnection con = new SqlConnection(connectionString);
            con.Open();

            string sqlQuery = "select SensorTypeId, SensorType from SENSOR_TYPE order by SensorType";
            SqlCommand cmd = new SqlCommand(sqlQuery, con);

            SqlDataReader dr = cmd.ExecuteReader();

            if (dr != null)
            {
                while (dr.Read())
                {
                    SensorType sensorType = new SensorType();

                    sensorType.SensorTypeId = Convert.ToInt32(dr["SensorTypeId"]);
                    sensorType.SensorTypeName = dr["SensorType"].ToString();

                    sensorTypeList.Add(sensorType);
                }
            }
            con.Close();
            return sensorTypeList;
        }
    }
}
```

Sensor.cs

```
using System.Data;
using System.Windows.Forms;
using Microsoft.Data.SqlClient;
using System.Configuration;

namespace SensorSystem.Classes
{
    class Sensor
    {
        string connectionString = ConfigurationManager.ConnectionStrings["DatabaseConnectionString"].ConnectionString;

        public void SaveSensorData(string sensorName, string sensorType, string unitName)
        {
            try
            {
                SqlConnection con = new SqlConnection(connectionString);
                con.Open();

                SqlCommand cmd = new SqlCommand("SaveSensor", con);
                cmd.CommandType = CommandType.StoredProcedure;

                cmd.Parameters.Add(new SqlParameter("@SensorName", sensorName));
                cmd.Parameters.Add(new SqlParameter("@SensorType", sensorType));
                cmd.Parameters.Add(new SqlParameter("@Unit", unitName));

                cmd.ExecuteNonQuery();
                con.Close();
            }
            catch
            {
                MessageBox.Show("Error Writing Data to Database");
            }
        }
    }
}
```

Form1.cs

```
using System;
using System.Collections.Generic;
using System.Windows.Forms;
using SensorSystem.Classes;

namespace SensorSystem
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
            FillSensorTypeComboBox();
        }

        private void btnSave_Click(object sender, EventArgs e)
        {
            SaveData();
        }
        private void FillSensorTypeComboBox()
        {
            SensorType sensorType = new SensorType();

            List<SensorType> sensorTypeList = new List<SensorType>();

            sensorTypeList = sensorType.GetSensorTypes();

            foreach (SensorType sensorTypeItem in sensorTypeList)
            {
                comboSensorType.Items.Add(sensorTypeItem.SensorTypeName);
            }
        }
        private void SaveData()
        {
            string sensorName = txtSensorName.Text;
            string sensorType = comboSensorType.SelectedItem.ToString();
            string unitName = txtUnit.Text;

            Sensor sensor = new Sensor();
            sensor.SaveSensorData(sensorName, sensorType, unitName);
        }
    }
}
```

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Datalogging

Windows Forms App #2

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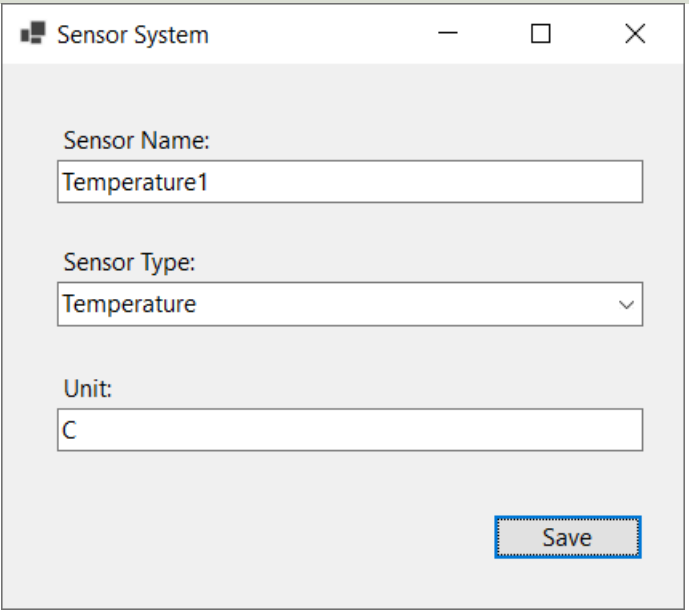
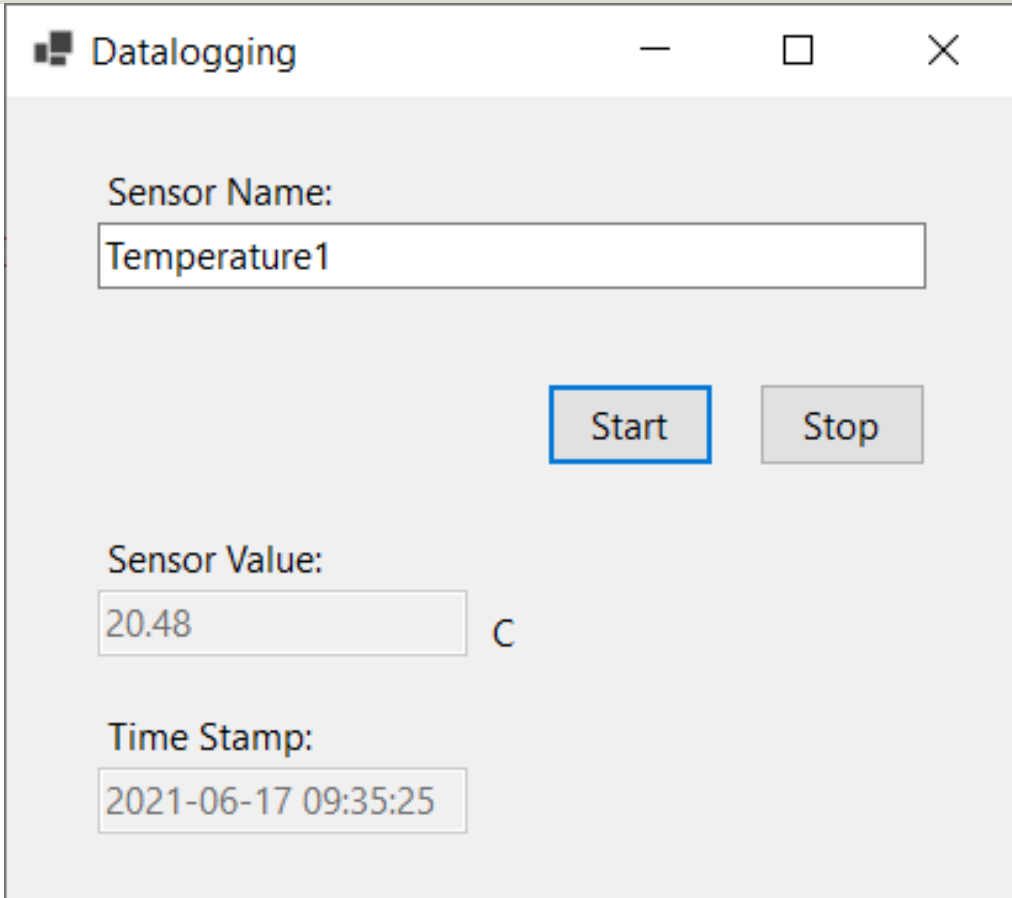
Datalogging

Windows Forms App #1

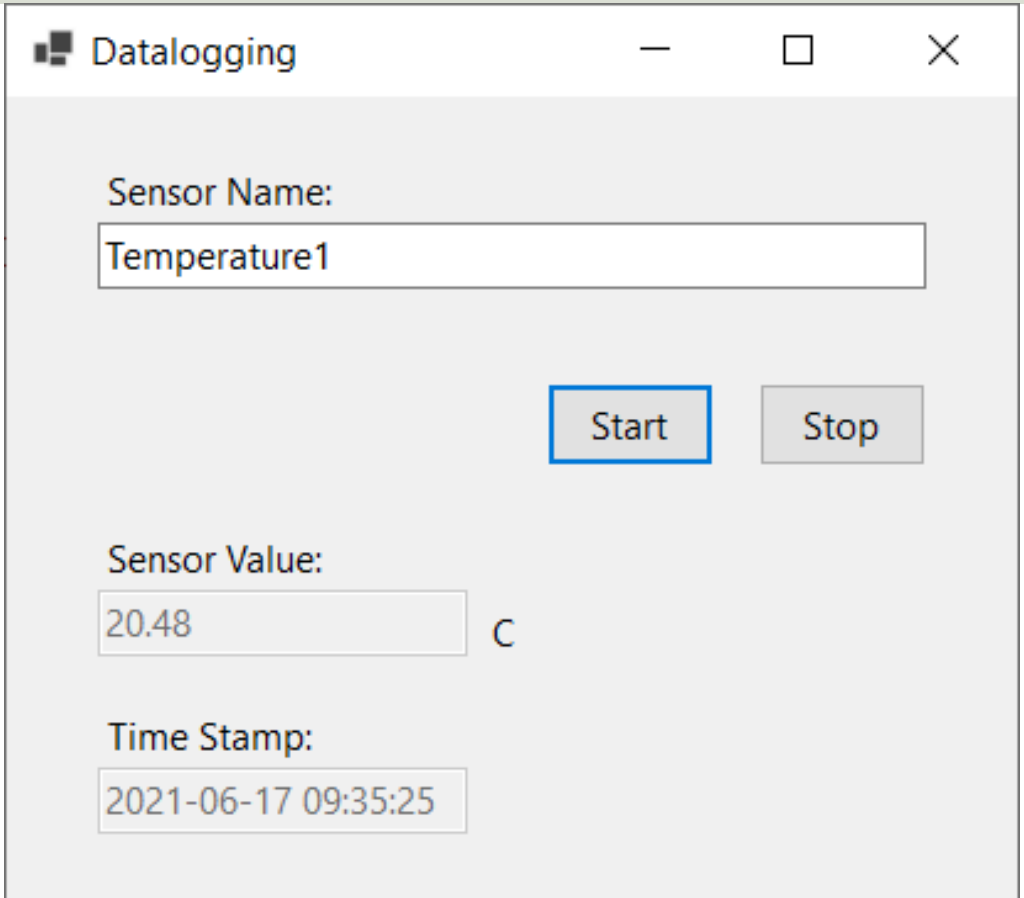


Windows Forms App #2



So far, we have a simple Windows Forms App for inserting different types of Sensors into an SQL Server.
Let's create another Windows Forms App that are Logging Data based on one of these Sensors

Datalogging Windows Forms App



SaveSensorData

```
IF EXISTS (SELECT name
   FROM   sysobjects
   WHERE  name = 'SaveSensorData'
   AND   type = 'P')
DROP PROCEDURE SaveSensorData
GO

CREATE PROCEDURE SaveSensorData
@SensorName varchar(50),
@SensorValue float,
@SensorDateTime datetime = null
AS

DECLARE
@SensorId int

SELECT @SensorId=SensorId FROM SENSOR WHERE SensorName=@SensorName

if @SensorDateTime is null
set @SensorDateTime = getdate()

INSERT INTO SENSOR_DATA (SensorId, SensorValue, SensorDateTime) VALUES (@SensorId, @SensorValue, @SensorDateTime)

GO
```

Test Data

SENSOR_TYPE:

```
insert into SENSOR_TYPE (SensorType) values ('Temperature')
insert into SENSOR_TYPE (SensorType) values ('Pressure')
insert into SENSOR_TYPE (SensorType) values ('Level')
insert into SENSOR_TYPE (SensorType) values ('Proximity ')
```

SENSOR:

```
insert into SENSOR (SensorName, SensorTypeId, Unit)
values ('Temperature1', (select SensorTypeId from
SENSOR_TYPE where SensorType='Temperature'), 'C')
```

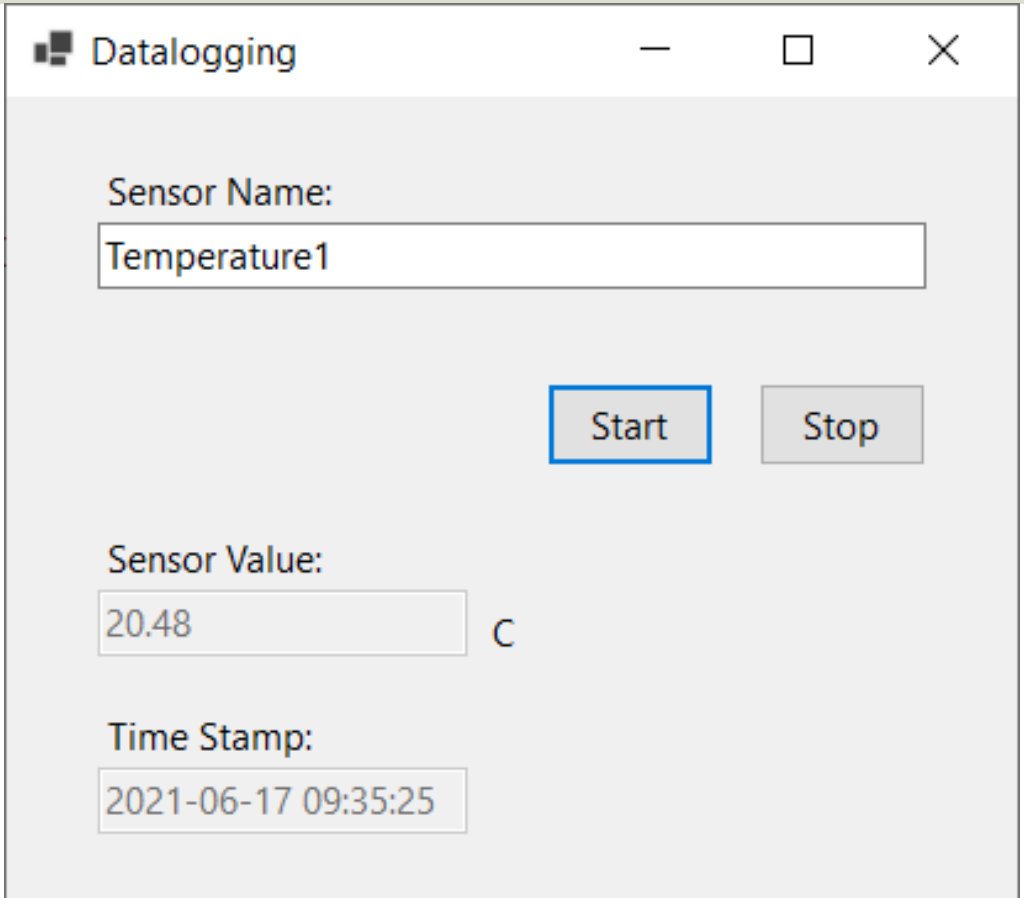
SensorData.cs

```
using System;
using System.Data;
using System.Windows.Forms;
using Microsoft.Data.SqlClient;
using System.Configuration;

namespace Datalogging.Classes
{
    class SensorData
    {
        string connectionString = ConfigurationManager.ConnectionStrings["DatabaseConnectionString"].ConnectionString;

        public string GetUnit(string sensorName)
        {
            string unitName="";

            SqlConnection con = new SqlConnection(connectionString);
            con.Open();

            string sqlQuery = "select Unit from SENSOR where SensorName=@SensorName";

            SqlCommand cmd = new SqlCommand(sqlQuery, con);

            cmd.Parameters.Add(new SqlParameter("@SensorName", sensorName));

            SqlDataReader dr = cmd.ExecuteReader();

            dr.Read();
            if (dr != null)
            {
                unitName = dr["Unit"].ToString();
            }
            con.Close();
            return unitName;
        }

        public void SaveSensorData(string sensorName, double sensorValue, DateTime sensorDateTime)
        {
            try
            {
                SqlConnection con = new SqlConnection(connectionString);
                con.Open();

                SqlCommand cmd = new SqlCommand("SaveSensorData", con);
                cmd.CommandType = CommandType.StoredProcedure;

                cmd.Parameters.Add(new SqlParameter("@SensorName", sensorName));
                cmd.Parameters.Add(new SqlParameter("@SensorValue", sensorValue));
                cmd.Parameters.Add(new SqlParameter("@SensorDateTime", sensorDateTime));

                cmd.ExecuteNonQuery();
                con.Close();
            }
            catch
            {
                MessageBox.Show("Error Writing Data to Database");
            }
        }
    }
}
```

Form1.cs

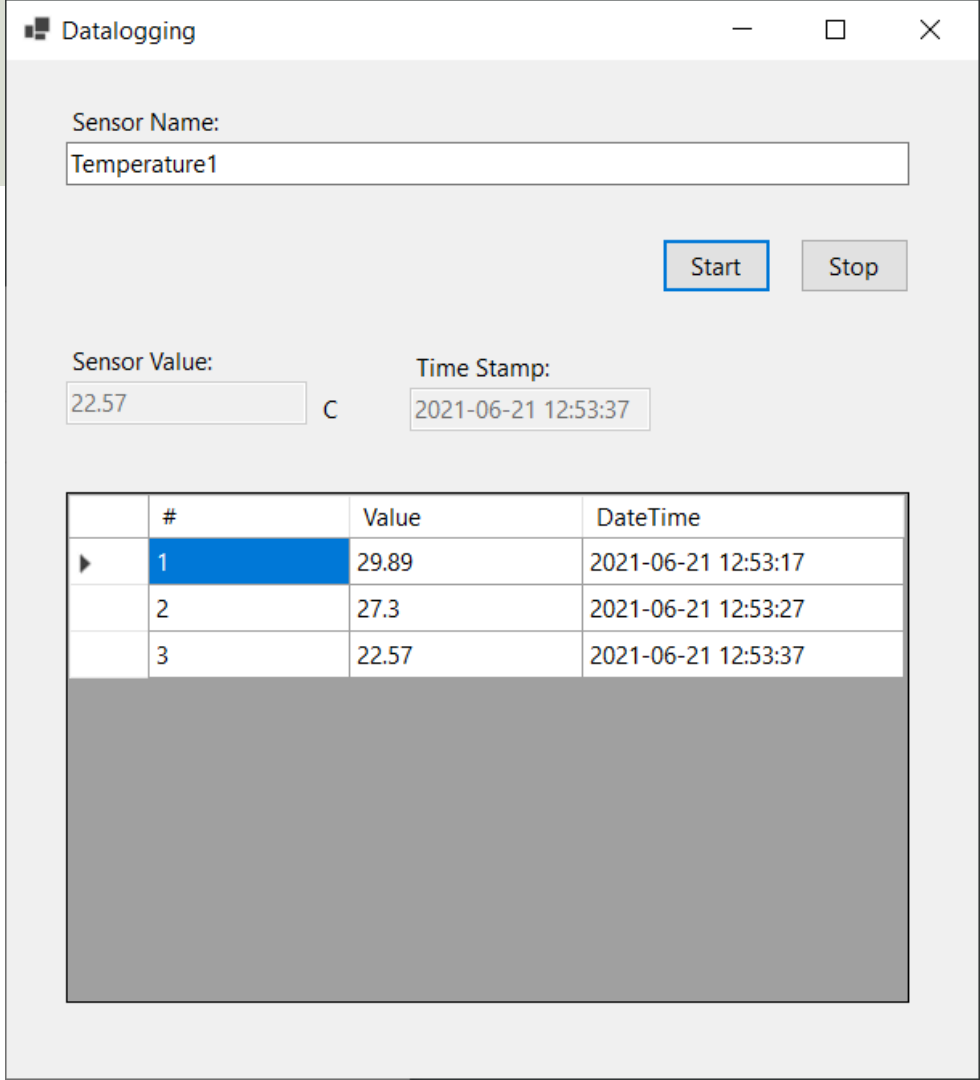
```
using System;
using System.Windows.Forms;
using Datalogging.Classes;

namespace Datalogging
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
            txtSensorName.Text = "Temperature1";
            timer1.Interval = 10000; //milliseconds
        }

        private void btnStartLogging_Click(object sender, EventArgs e)
        {
            timer1.Enabled = true;
            timer1.Start();
        }

        private void btnStopLogging_Click(object sender, EventArgs e)
        {
            timer1.Stop();
            timer1.Enabled = false;
        }

        private void timer1_Tick(object sender, EventArgs e)
        {
            Datalogging();
        }

        void Datalogging()
        {
            string sensorName;
            var rand = new Random();
            int minValue = 20, maxValue = 30;
            double sensorValue;
            sensorName = txtSensorName.Text;

            // Generate SensorValue
            sensorValue = rand.NextDouble() * (maxValue-minValue) + minValue;
            txtSensorValue.Text = sensorValue.ToString("#.##");
            DateTime sensorDateTime = DateTime.Now;
            txtTimeStamp.Text = sensorDateTime.ToString("yyyy-MM-dd HH:mm:ss");

            SensorData sensorData = new SensorData();
            // Get Unit
            lblUnit.Text = sensorData.GetUnit(sensorName);

            // Save SensorData to Database
            sensorData.SaveSensorData(sensorName, sensorValue, sensorDateTime);
        }
    }
}
```

Datalogging Windows Forms App



DataGridView

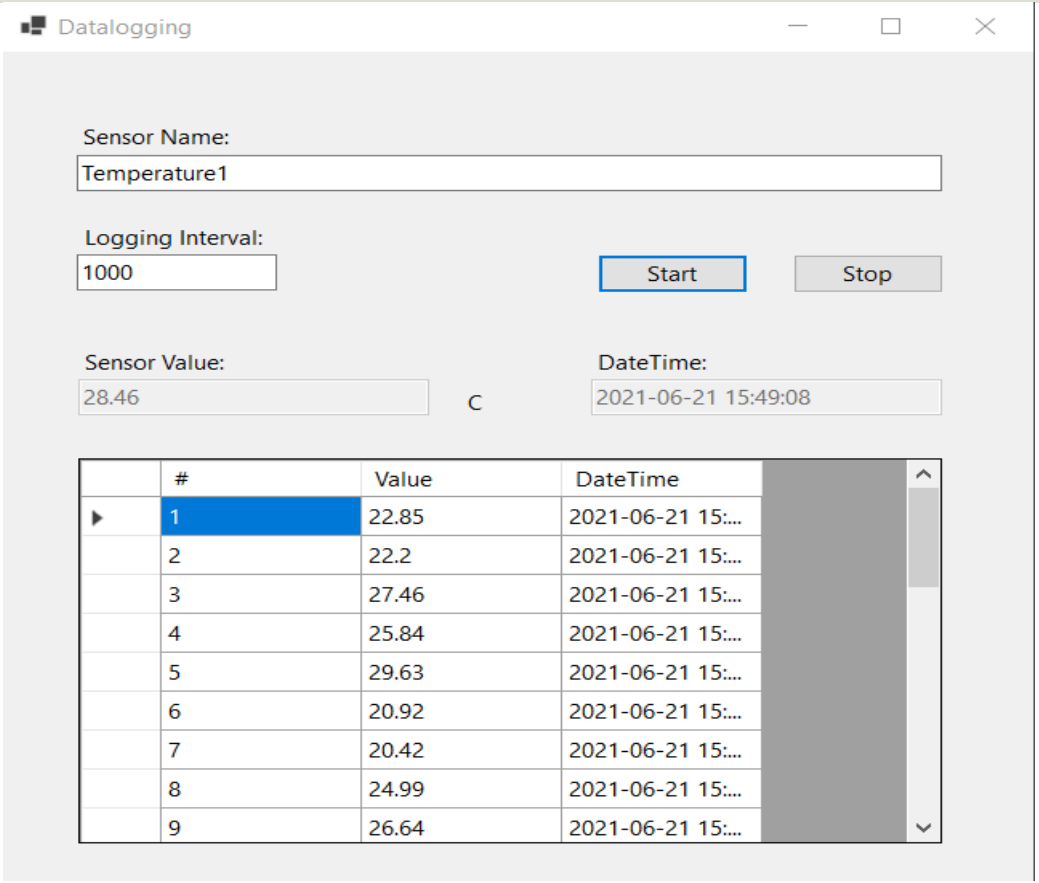
We can use a DataGridView for showing Historical Data



Updated Datalogging() Method

```
int loggingIndex = 0;
void Datalogging()
{
            string sensorName;
            var rand = new Random();
            int minValue = 20, maxValue = 30;
            double sensorValue;

            sensorName = txtSensorName.Text;

            // Generate SensorValue
            sensorValue = rand.NextDouble() * (maxValue-minValue) + minValue;
            txtSensorValue.Text = sensorValue.ToString("#.##");
            DateTime sensorDateTime = DateTime.Now;
            txtTimeStamp.Text = sensorDateTime.ToString("yyyy-MM-dd HH:mm:ss");

            //Update GridView
            DataGridViewRow row = new DataGridViewRow();
            row.CreateCells(dgvLoggedData);

            loggingIndex++;
            row.Cells[0].Value = loggingIndex;
            row.Cells[1].Value = sensorValue.ToString("#.##");
            row.Cells[2].Value = sensorDateTime.ToString("yyyy-MM-dd HH:mm:ss");
            dgvLoggedData.Rows.Add(row);

            SensorData sensorData = new SensorData();
            // Get Unit
            lblUnit.Text = sensorData.GetUnit(sensorName);

            // Save SensorData to Database
            sensorData.SaveSensorData(sensorName, sensorValue, sensorDateTime);
}
```

Final Datalogging App



Discussions

- We have made a simple Windows Forms App for Logging Sensor Data to a SQL Server Database
- The examples provided can be considered as a “proof of concept”
- The sample code is very simplified for clarity and doesn't necessarily represent best practices.
- First, I made it work, then I improved the code step by step
- Still, lots of improvements to make, but I leave that for you

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