GLOSSARY

AWS – Amazon Web Services

CMRR – Common Mode Rejection Ratio

CORS – Cross-Origin Resource Sharing

DNS – Dinitrosalicylic Acid

GMS – Glucose Monitoring System

GOx – Glucose Oxidase

HTML – Hypertext Markup Language

IDF – International Diabetic Federation

IoT – Internet of Things

ISO – International Organization of Standardization

JSON – JavaScript Object Notation

MQTT – Message Queing Telemetry Transpor

PoCT – Point of Care Test

RE – Reference Electrode

SMA – Simple Moving Average

SQL – Structured Query Language

S3 – Amazon Simple Storage Service

WE – Working Electrode

WHO – World Health Organization

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APPENDICES

Appendix A – Codes

- **ESP32 Code**

```
// Glucometer ESP32 Code
// by: Tanita Grace
// 2023

const int pin = 33;// Analog pin
int pinValue;// do not change
float voltage =0;// do not change
float voltageInput[] = {};
int sampleCounter = 0 ;
float avrgVoltage = 0.0;
#define window_size 10
float window[window_size] = {0};
float glucose=0;
int i;

#include "secrets.h"
#include <WiFiClientSecure.h>
#include <PubSubClient.h>
#include <ArduinoJson.h>
#include "WiFi.h"
#define AWS_IOT_PUBLISH_TOPIC   "publishme" //IoT Topic

WiFiClientSecure net = WiFiClientSecure();
PubSubClient client(net);

void connectAWS()
{
  WiFi.mode(WIFI_STA);
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.println("Connecting to Wi-Fi");

  while (WiFi.status() != WL_CONNECTED)
  {
    delay(500);
    Serial.print(".");

  }

  // Configure WiFiClientSecure to use the AWS IoT device
credentials
  net.setCACert(AWS_CERT_CA);
  net.setCertificate(AWS_CERT_CRT);
  net.setPrivateKey(AWS_CERT_PRIVATE);

```

```
  // Connect to the MQTT broker on the AWS endpoint we defined earlier
  client.setServer(AWS_IOT_ENDPOINT, 8883);
  Serial.println("Connecting to AWS IOT");

  while (!client.connect(THINGNAME))
  {
    Serial.print(".");
    delay(100);
  }

  if (!client.connected())
  {
    Serial.println("AWS IoT Timeout!");
    return;
  }

  Serial.println("AWS IoT Connected!");
}

void publishMessage()
{
  StaticJsonDocument<200> doc;
  String myStr;
  myStr = String(glucose);
  doc["glucose"] = myStr;
  char jsonBuffer[512];
  if (glucose!=0){
  serializeJson(doc, jsonBuffer); // print to client
  client.publish(AWS_IOT_PUBLISH_TOPIC, jsonBuffer);
}
}


void push(float val){
  int i = 0;
  for (i=1; i<window_size; i++){
    window[i-1] = window[i];
  }
  window[window_size-1] = val;
}


float take_avg(){
  float sum =0;
  int i = 0;
  for(i=0; i<window_size; i++){
    sum += window[i];
  }
  return sum/window_size;
}
```

```
•
•
•  void setup() {
•    // initialize serial communication at 115200 bits per second:
•    Serial.begin(115200);
•    connectAWS();
•  }
•
•  void loop() {
•   // read the input on analog pin potPin:
•    pinValue = analogRead(pin);
•    voltage = (3.3/4095.0) * pinValue;
•    push(voltage);
•
•    if(voltage > 2.45){
•     sampleCounter++;
•     if (sampleCounter<32){
•     voltageInput[sampleCounter] = take_avg();  //every float
   sample occupied 4 memory locations
•     Serial.println(voltageInput[sampleCounter]);
•     delay(200);
•
•     //Serial.println(sampleCounter);
•     //sampleCounter++;
•     if (sampleCounter == 31)  //20 samples are collected
•     {
•       for (i = 20; i<sampleCounter; i++)
•       {
•        avrgVoltage += voltageInput[i];   //all 20 samples are
   added
•      }
•      avrgVoltage = avrgVoltage / 11;
•      glucose = (avrgVoltage - 2.405073)/(0.0010523);
•      publishMessage();
•      client.loop();
•      Serial.print("Average=");
•      Serial.println(avrgVoltage,7);
•      Serial.print("glucose=");
•      Serial.println(glucose);
•      Serial.println("=========================================
   =====");
•
•     }
•
•      }
•    }
•  }
```

- **CORS for Bucket**


```
[
  {
    "AllowedHeaders": [
      "Authorization"
    ],
    "AllowedMethods": [
      "GET"
    ],
    "AllowedOrigins": [
      "*"
    ],
    "ExposeHeaders": [],
    "MaxAgeSeconds": 3000
  }
]
```


- **Bucket Policy**


```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "PublicRead",
      "Effect": "Allow",
      "Principal": "*",
      "Action": "s3:GetObject",
      "Resource": "arn:aws:s3:::testsdatabucket/*"
    }
  ]
}
```

- **Index.html to display glucose concentration**

```
<!DOCTYPE html>
<html lang="en">

<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <meta http-equiv="X-UA-Compatible" content="ie=edge">
    <title>Glucose Reading</title>
</head>

<body>


    <script src="https://code.highcharts.com/highcharts.js"></script>

    <div class="container1">
        <h1>Glucometer Data</h1>


        <div class="panel panel-info">
            <div class="panel-body">
                <div id="container1"></div>
            </div>
        </div>


    </div>

    <script>

    var x = new XMLHttpRequest();
    x.open("GET", "https://testsdatabucket.s3.amazonaws.com/", true);
    // x.setRequestHeader("Content-Type", "application/xml");
    x.onreadystatechange = function () {
        if (x.readyState == 4 && x.status == 200) {
            let promiseArr = [];
            let data = [];
            var doc = x.responseXML;
            let keys = doc.getElementsByTagName("Key");

            let index = 0;
            createDataSet(index);

            function createDataSet(index) {
                if (index >= keys.length) {
                    generateGraph();
                    return false;
                }
                let element = keys[index];
                element = element.textContent;

                let splitName = element.split('/');
                if (splitName[0] === 'testfolder' && splitName[1] !== '') {
                    promiseArr.push(new Promise((resolve, reject) => {
                        var innerReq = new XMLHttpRequest();
                        innerReq.open("GET", "https://testsdatabucket.s3.amazonaws.com/" + splitName[0] + "/" + splitName[1], true);
                        // innerReq.setRequestHeader("Content-Type", "application/xml");
                        innerReq.onreadystatechange = function () {
                            if (innerReq.readyState == 4 && innerReq.status == 200) {
                                let parseData = JSON.parse(innerReq.responseText);
                                if (parseData.glucose) {
                                    data.push(Object.assign({}, parseData, { timestamp: splitName[1] }));
                                }
                                resolve('Done')
                                index++;
                                createDataSet(index);
                            } else {
                                // reject(innerReq)
                            }
                        }
                        innerReq.send(null);
                    }));
                } else {
                    index++;
                    createDataSet(index);
                }
            }
```

```
function generateGraph() {
    Promise.all(promiseArr.map(p => p.catch(e => e)))
        .then(res => {

            abcData = data;
            let lineXaxisData = [], glcArr = [], timeArr = [];
            for (let i = 0; i < abcData.length; i++) {

                glcArr.push(Number(abcData[i].glucose));
                //timeArr.push(Number(abcData[i].uptime));
                timeArr.push(new Date(Number(abcData[i].timestamp)).toLocaleString());
            }

            var chart = Highcharts.chart('container1', {

                title: {
                 plotOptions: {
                     series: {
                         label: {
                             connectorAllowed: false
                         }
                     }
                 },
                 series: [{
                     name: 'Glucose Concentration (mg/dl)',
                     data: glcArr
                 }],

                 responsive: {
                     rules: [{
                         condition: {
                             maxWidth: 500
                         },
                         chartOptions: {
                             legend: {
                                 layout: 'horizontal',
                                 align: 'center',
                                 verticalAlign: 'bottom'
                             }
                         }
                     }]
                 }

             });
        }).catch(err => {
            console.log('err', err)
        })
    }

}
};
x.send(null);
```

Appendix B – Schematic

- **LMC6484 Pinouts**

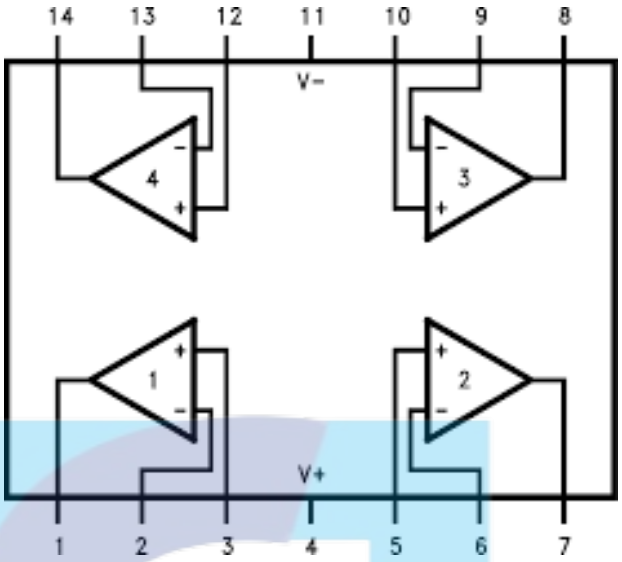


Figure B.1. LMC6484 pinouts

Appendix C – Measurement Result

- **Glucose Solution Response – Batch 1**

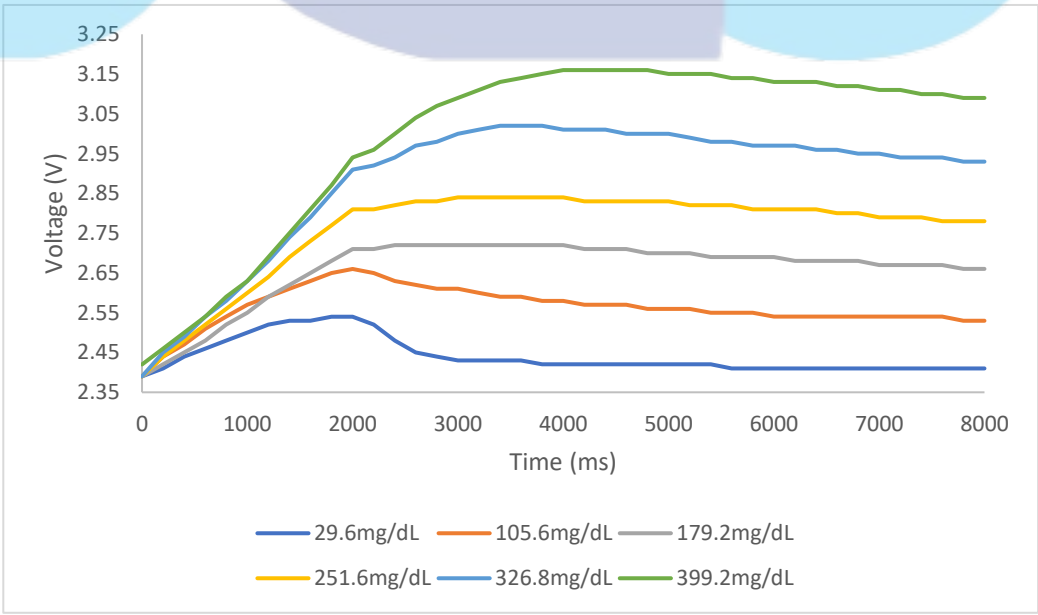


Figure C.1. Glucose solution response – batch 1

- **Glucose Solution Response – Batch 2**

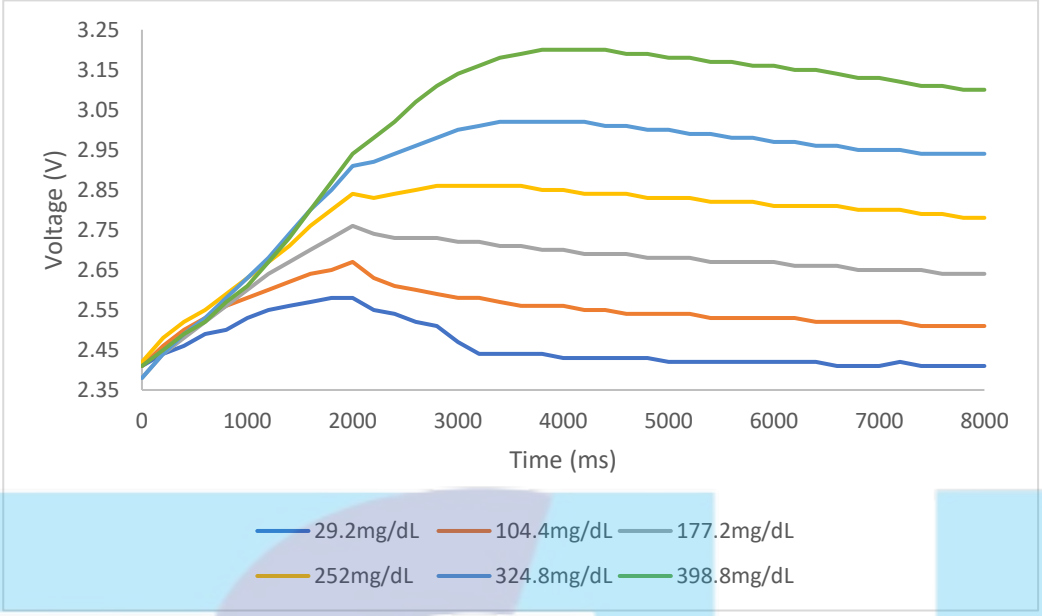


Figure C.2. Glucose solution response – batch 2

- **Absorbance of Glucose Solution – Batch 1**

Table C.1. Absorbance of glucose solution – batch 1

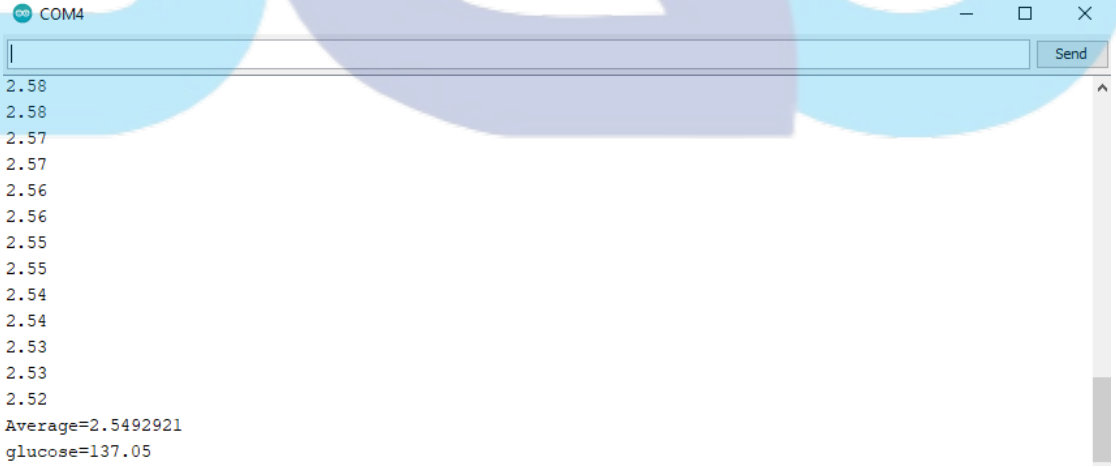
Concentration (mg/dl)	Absorbance
5.92	0.078
21.12	0.4085
35.84	0.8755
50.32	1.228
65.36	1.583
79.84	1.7305

- **Absorbance of Glucose Solution – Batch 2**

Table C.2. Absorbance of glucose solution – batch 2

Concentration (mg/dl)	Absorbance
5.84	0.0975
20.88	0.406
35.44	0.8055
50.4	1.2125
64.96	1.5335
79.76	1.7925

- **Blood Glucose Measurement Result in Serial Monitor**



Appendix D – Informed Consent

LEMBAR PENJELASAN KEPADA CALON SUBJEK

Saya, **Tanita Grace** dari **departemen Teknik Biomedis Swiss German University** sedang melakukan skripsi dengan judul **'Development of an IoT-Based Glucometer for Telemedicine Application in Jakarta'**.

Saya akan memberikan informasi kepada Bapak/Ibu/Saudara mengenai penelitian ini dan mengundang Bapak/Ibu/Saudara untuk menjadi bagian dari penelitian ini.
Bapak/Ibu/Saudara dapat berpartisipasi dalam penelitian ini dengan cara menandatangani formulir ini. Apabila kurang berkenan, Bapak/Ibu/Saudara dapat menolak untuk berkontribusi dalam penelitian ini. Jika Bapak/Ibu/Saudara menolak untuk berpartisipasi, keputusan tersebut tidak akan mempengaruhi hubungan Bapak/Ibu/Saudara dengan saya.
Jika Bapak/Ibu/Saudara tidak mengerti tiap pernyataan dalam formulir ini, Bapak/Ibu/Saudara dapat menanyakannya kepada saya.

1. **Tujuan Penelitian**

Tujuan dari penelitian ini adalah untuk mengembangkan glukometer (alat cek gula darah) yang dapat mengukur kadar gula darah manusia, terutama pada penderita diabetes. Selain itu, penelitian ini ditujukan juga untuk mengembangkan *platform* yang dapat menampilkan dan menyimpan hasil pengukuran gula darah, serta mengintegrasikan fitur telemedicine pada alat tersebut.

2. **Partisipasi dalam Penelitian**

Prinsip utama penelitian ini adalah pengukuran kadar gula darah menggunakan alat yang saya kembangkan. Prosedur pengukuran gula darah yang dilakukan sama dengan prosedur menggunakan glukometer pada umumnya. Pengambilan sampel darah hanya akan dilakukan satu kali. Hasil yang diperoleh akan digunakan sebagai data untuk kalibrasi dan/atau validasi.

3. **Alasan memilih Bapak/Ibu/Saudara**

Alasan Bapak/Ibu/Saudara dipilih adalah dikarenakan Bapak/Ibu/Saudara memiliki kadar gula darah yang dapat dijadikan data penunjang untuk skripsi saya.

4. **Prosedur penelitian**

- Bapak/Ibu/Saudara akan diberikan lembar consent yang menjelaskan prosedur dan tata penelitian serta resiko dan manfaat.
- Bapak/Ibu/Saudara boleh memilih untuk ikut ataupun menolak untuk berkontribusi dalam penelitian ini.

- Bapak/Ibu/Saudara yang memilih untuk ikut akan diukur kadar gula darahnya menggunakan glukometer AccuChek Instant dan glukometer yang sedang saya kembangkan.
- Pengukuran gula darah dilakukan dengan menusukan jarum ke jari tangan. Kemudian, darah yang keluar akan dimasukan ke dalam *test strip*. Hasil gula darah akan keluar dalam hitungan detik.
- Pengecekan gula darah hanya akan dilakukan 1 kali.
- *Reward* akan diberikan kepada Bapak/Ibu/Saudara setelah pengecekan selesai.

5. Risiko, efek samping dan tatalaksananya

Glukometer merupakan alat yang memiliki risiko rendah dan membutuhkan jumlah darah yang sangat kecil. Efek samping yang dapat timbul setelah menggunakan alat ini adalah rasa nyeri/sakit dan infeksi pada area yang ditusuk jarum.

6. Manfaat

Manfaat yang diberikan dalam pengetesan ini adalah pengecekan kadar gula darah sesaat Bapak/Ibu/Saudara secara gratis.

7. Kompensasi

Bapak/Ibu/Saudara akan diberikan *reward* berupa biskuit setelah pengecekan selesai.

8. Pembiayaan

Penelitian ini dibiayai secara pribadi dan juga oleh tim peneliti dari Swiss German University.

9. Kerahasiaan

Semua data penelitian ini akan diperlakukan secara rahasia. Hasil kadar gula yang akan diperoleh dan ditulis dalam laporan penelitian tidak akan mencantumkan nama maupun informasi pribadi lain Bapak/Ibu/Saudara.

10. Kewajiban subjek

Agar pengambilan data berjalan dengan lancar, Bapak/Ibu/Saudara diharapkan untuk mengikuti arahan saya saat pengecekan gula darah akan dilakukan.

11. Hak untuk menolak dan mengundurkan diri

Bila kurang berkenan, Bapak/Ibu/Saudara bebas menolak ikut dalam penelitian ini. Bapak/Ibu/Saudara diberi kesempatan untuk menanyakan semua hal yang belum jelas sehubungan dengan penelitian ini.

12. Akses pasca penelitian (post-trial access)

Pada akhir penelitian ini, Bapak/Ibu/Saudara akan diberikan *reward* berupa biskuit. Bapak/Ibu/Saudara juga diperbolehkan untuk menyimpan hasil cek gula darah.

13. Informasi tambahan

Bila sewaktu-waktu terjadi efek samping atau membutuhkan penjelasan tambahan menyangkut penelitian ini, Bapak/Ibu/Saudara dapat menghubungi, saya sebagai peneliti di departemen teknik Biomedis Swiss German University, Jalan Jalur Sutera Barat no. 15, Alam Sutera, Banten dengan No. Handphone +6281905565566.

No.

LEMBAR PERSETUJUAN KEIKUTSERTAAN DALAM PENELITIAN

Semua penjelasan tersebut telah disampaikan kepada saya dan semua pertanyaan saya telah dijawab peneliti**.** Saya mengerti bahwa bila memerlukan penjelasan, saya dapat menanyakan kepada Tanita Grace, selaku peneliti dari Swiss German University.

Sertifikat Persetujuan (*Consent*)	
Saya telah membaca semua penjelasan tentang penelitian ini. Saya telah diberikan kesempatan untuk bertanya dan semua pertanyaan saya telah dijawab dengan jelas. Saya bersedia untuk berpartisipasi pada studi penelitian ini dengan sukarela. _____ Nama subjek _____ Tanda tangan peserta studi Tanggal_____ hari/bulan/tahun	Saya mengkonfirmasi bahwa peserta telah diberikan kesempatan untuk bertanya mengenai penelitian ini, dan semua pertanyaan telah dijawab dengan benar. Saya mengkonfirmasi bahwa persetujuan telah diberikan dengan sukarela. _____ Nama peneliti _____ Tanda tangan peneliti Tanggal_____ hari/bulan/tahun

Informasi Peneliti:

Peneliti: Tanita Grace
Jalan Jalur Sutera Barat no. 15, Alam Sutera, Banten
No. Telp: +62 81905565566
Email: tanita,grace@student.sgu.ac.id

CURRICULUM VITAE

PERSONAL DATA

Name	: Tanita Grace
Address	: Taman Surya 5 Blok JJ 5/20 RT 004 RW 017, Kel. Pegadungan, Kec. Kalideres, Jakarta Barat, DKI Jakarta
Contact Number	: +62 819 0556 5566
Email Address	: tanitagrace.k@gmail.com
Place and Date of Birth	: Jakarta, 20th November 2001

EDUCATION

2019 — 2023	**Swiss German University, Alam Sutera, Tangerang** Biomedical Engineering Department
2020	**Spitze Studium Jakarta, German Learning Centre**
2016 — 2019	**SMA Ipeka Puri Indah (Senior High School), Jakarta Barat** Natural Sciences

ACHIEVEMENTS

2021	**Grant for "Production of Polylactic Acid (PLA) from Banana Hump as Raw Material for Biodegradable Surgical Thread" Research** Program Kreativitas Mahasiswa - Riset (PKM-R) Directorate General of Learning and Student Affairs Ministry of Research, Technology and Higher Education of the Republic of Indonesia
2019	**Second Winner of Basketball Competition** Province Level Porprov DKI Jakarta
2018	**Second Winner of Basketball Competition** International Level Tong Lu Cup, Hang Zhou
2017	**Second Winner of Basketball Competition** International Level Qian Xi Cup, Singapore

ORGANISATION EXPERIENCES

Biomedical Engineering Student Association (BESt)

2021	Head of Committee of Life Sciences and Technology Charity
2020 — 2021	President
2019 — 2020	Member of Fund Raising Division

Student Board of Executives (SBOE)

2021	Vice Head of Committee of SGU E-Sport External League
2020 — 2021	Member of Sport Division

SMA Ipeka Puri Indah

2018	Member of Event Division of SKIPIJAM

Orang Muda Katolik (OMK) Wilayah 3 - Kalideres Parish

2022 — Present	Treasurer

WORKING EXPERIENCE

March — August 2022	**Labor Mönchengladbach MVZ Dr. Stein + Kollegen** Internship in Instrumental Analytics Department
September — December 2021	**Neurabot** Internship (Development of Image Augmentation GUI)
July — August 2021	**Universitas Gadjah Mada** Internship (Development of Electronic Tongue)

SKILLS

Language Skills	Indonesian (Mother Tongue), English (Intermediate), German (A2)
Software Skills	Microsoft Office (PowerPoint, Word, Excel), Arduino IDE, FreeCAD, KiCAD, Filmora
Programming Language	Python, C++