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Computer Assignment 1

1.รายละเอียดของทฤษฎีหรือวิธีการต่าง ๆ ที่ใช้

1. $\vec{\hat{\mu}} = \frac{1}{n}\sum_{k=1}^{n}\vec{x}_k \qquad \vec{\mu} = \begin{bmatrix} \mu_1 \\ : \\ \mu_2 \end{bmatrix}$;Mean vector

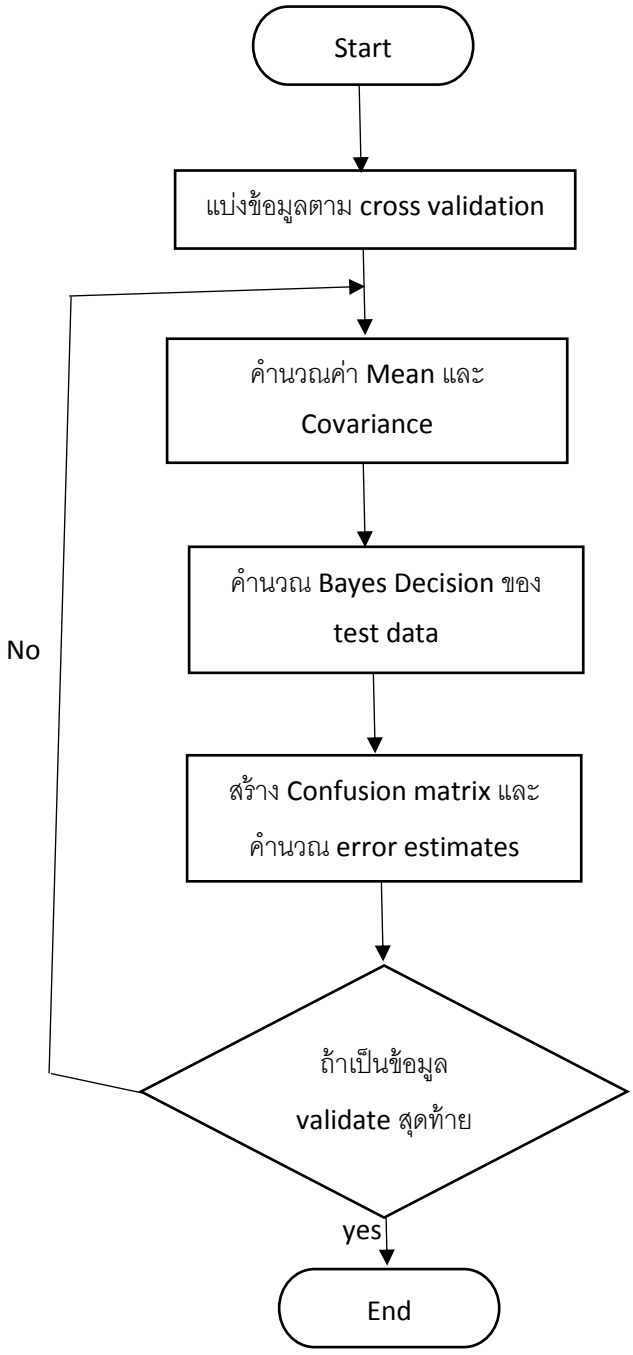
2. $\overline{\overline{\varepsilon}} = \frac{1}{n}\sum_{k=1}^{n}(\vec{x}_k - \vec{\hat{\mu}})^T(\vec{x}_k - \vec{\hat{\mu}}) \qquad \overline{\overline{\varepsilon}} = \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1d} \\ : & & : \\ \sigma_{d1} & \cdots & \sigma_{dd} \end{bmatrix}$;Covariance matrices

3. $N(\vec{x};\mu,\overline{\overline{\varepsilon}}) = \frac{1}{(2\pi)^{n/2}\left|\overline{\overline{\varepsilon_i}}\right|^{1/2}}\exp(-\frac{1}{2}(\vec{x}-\mu_i)^t\overline{\overline{\varepsilon}}_i^{-1}(\vec{x}-\mu_i))$;Conditional probability

4. $\frac{f(\vec{x}/w_1)}{f(\vec{x}/w_2)} > \frac{\lambda_{22}-\lambda_{12}}{\lambda_{11}-\lambda_{21}}\frac{P(w2)}{P(w1)}$;Risk Bayes Decision Theoretic

5. ใช้ NodeJS ในการพัฒนาซอฟท์แวร์

2.Flowchart


Start
แบ่งข้อมูลตาม cross validation
คำนวณค่า Mean และ Covariance
คำนวณ Bayes Decision ของ test data
สร้าง Confusion matrix และ คำนวณ error estimates
ถ้าเป็นข้อมูล validate สุดท้าย
No
yes
End

3. ผลการทดลอง

เมื่อทดลองกับ 2 feature

```
---------- Validation 1 --------------
Mean class 1 : |  6.369375000000001 2.9028749999999994 |
Mean class 2 : |  6.601400000000001 2.9025 |

Covariance matrices
|  0.281340859375 -0.021145703124999984 |
|  -0.021145703124999984 0.11748798437499999 |

Confusion matrix
| 13 7 |
| 0 0 |

correct 65 %
error 35 %
--------------------------------

---------- Validation 2 --------------
Mean class 1 : |  6.3648750000000005 2.9117499999999996 |
Mean class 2 : |  6.601400000000001 2.9025 |

Covariance matrices
|  0.30457998437500033 -0.020507281249999985 |
|  -0.020507281249999985 0.1194469375 |

Confusion matrix
| 13 7 |
| 0 0 |

correct 65 %
error 35 %
--------------------------------

---------- Validation 3 --------------
Mean class 1 : |  6.328000000000001 2.9393749999999996 |
Mean class 2 : |  6.601400000000001 2.9025 |

Covariance matrices
|  0.2963835 -0.02533999999999999 |
|  -0.02533999999999999 0.12486085937499998 |

Confusion matrix
| 10 10 |
| 0 0 |

correct 50 %
error 50 %
--------------------------------
```

```
---------- Validation 4 --------------
Mean class 1 : |  6.328499999999999 2.9276249999999995 |
Mean class 2 : |  6.601400000000001 2.9025 |

Covariance matrices
|  0.3060902499999999 -0.011257312499999993 |
|  -0.011257312499999993 0.105040609375 |

Confusion matrix
| 13 7 |
| 0 0 |

correct 65 %
error 35 %
--------------------------------

---------- Validation 5 --------------
Mean class 1 : |  6.36125 2.9268749999999994 |
Mean class 2 : |  6.601400000000001 2.9025 |

Covariance matrices
|  0.33078593749999996 -0.017017343749999997 |
|  -0.017017343749999997 0.09231648437499998 |

Confusion matrix
| 11 9 |
| 0 0 |

correct 55 %
error 45 %
--------------------------------

---------- Validation 6 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 |
Mean class 2 : |  6.636374999999997 2.903250000000001 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 |
|  -0.01924767999999999 0.11199610999999994 |

Confusion matrix
| 0 0 |
| 13 7 |

correct 35 %
error 65 %
--------------------------------
```

```
---------- Validation 7 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 |
Mean class 2 : |  6.599874999999997 2.902000000000001 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 |
|  -0.01924767999999999 0.11199610999999994 |

Confusion matrix
| 0 0 |
| 11 9 |

correct 45 %
error 55 %
--------------------------------

---------- Validation 8 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 |
Mean class 2 : |  6.571874999999997 2.8836250000000003 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 |
|  -0.01924767999999999 0.11199610999999994 |

Confusion matrix
| 0 0 |
| 6 14 |

correct 70 %
error 30 %
--------------------------------

---------- Validation 9 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 |
Mean class 2 : |  6.605249999999998 2.9152499999999995 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 |
|  -0.01924767999999999 0.11199610999999994 |

Confusion matrix
| 0 0 |
| 12 8 |

correct 40 %
error 60 %
--------------------------------
```

```
---------- Validation 10 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 |
Mean class 2 : |  6.593625 2.9083750000000004 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 |
|  -0.01924767999999999 0.11199610999999994 |

Confusion matrix
| 0 0 |
| 8 12 |

correct 60 %
error 40 %
--------------------------------
```

เมื่อทดลองกับ 4 feature

```
---------- Validation 1 --------------
Mean class 1 : |  6.369375000000001 2.9028749999999994 4.240500000000001 1.307875 |
Mean class 2 : |  6.601400000000001 2.9025 5.623699999999998 2.0549999999999997 |

Covariance matrices
|  0.281340859375 -0.021145703124999984 0.02807781250000001 -0.016707578124999997 |
|  -0.021145703124999984 0.11748798437499999 -0.006667687500000004 -0.00010514062500000193 |
|  0.02807781250000001 -0.006667687500000004 0.1550172499999999 0.015594812499999989 |
|  -0.016707578124999997 -0.00010514062500000193 0.015594812499999989 0.033676734375 |

Confusion matrix
| 20 0 |
| 0 0 |

correct 100 %
error 0 %
--------------------------------

---------- Validation 2 --------------
Mean class 1 : |  6.3648750000000005 2.9117499999999996 4.232375000000001 1.3014999999999999 |
Mean class 2 : |  6.601400000000001 2.9025 5.623699999999998 2.0549999999999997 |

Covariance matrices
|  0.30457998437500033 -0.020507281249999985 0.028030921874999993 -0.01464606250000001 |
|  -0.020507281249999985 0.1194469375 -0.006691656250000003 0.005682375000000002 |
|  0.028030921874999993 -0.006691656250000003 0.14887810937499998 0.010608937499999993 |
|  -0.01464606250000001 0.005682375000000002 0.010608937499999993 0.04081025000000002 |

Confusion matrix
| 20 0 |
| 0 0 |

correct 100 %
error 0 %
--------------------------------

---------- Validation 3 --------------
Mean class 1 : |  6.328000000000001 2.9393749999999996 4.203000000000001 1.2985 |
Mean class 2 : |  6.601400000000001 2.9025 5.623699999999998 2.0549999999999997 |

Covariance matrices
|  0.2963835 -0.025339999999999999 0.013398499999999966 -0.0020380000000000034 |
|  -0.025339999999999999 0.12486085937499998 -0.01818562500000001 0.006904062500000001 |
|  0.013398499999999966 -0.01818562500000001 0.1635185 0.020653249999999988 |
|  -0.0020380000000000034 0.006904062500000001 0.020653249999999988 0.04076275 |

Confusion matrix
| 20 0 |
| 0 0 |

correct 100 %
error 0 %
--------------------------------
```

```
---------- Validation 4 --------------
Mean class 1 : |  6.328499999999999 2.9276249999999995 4.207375000000001 1.295125 |
Mean class 2 : |  6.601400000000001 2.9025 5.623699999999998 2.0549999999999997 |

Covariance matrices
|  0.3060902499999999 -0.011257312499999993 0.025039812499999998 -0.014812312500000006 |
|  -0.011257312499999993 0.105040609375 -0.006343734375000009 0.007082171874999998 |
|  0.025039812499999998 -0.006343734375000009 0.14476685937500003 0.013334703124999998 |
|  -0.014812312500000006 0.007082171874999998 0.013334703124999998 0.040434984375000003 |

Confusion matrix
| 19 1 |
| 0 0 |

correct 95 %
error 5 %
--------------------------------

---------- Validation 5 --------------
Mean class 1 : |  6.36125 2.9268749999999994 4.194749999999999 1.271 |
Mean class 2 : |  6.601400000000001 2.9025 5.623699999999998 2.0549999999999997 |

Covariance matrices
|  0.33078593749999996 -0.017017343749999997 0.034995312500000014 -0.009652500000000012 |
|  -0.017017343749999997 0.09231648437499998 0.00115109375 0.009499374999999997 |
|  0.034995312500000014 0.00115109375 0.1448399375 0.013088999999999993 |
|  -0.009652500000000012 0.009499374999999997 0.013088999999999993 0.037364 |

Confusion matrix
| 18 2 |
| 0 0 |

correct 90 %
error 10 %
--------------------------------

---------- Validation 6 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 4.2156 1.2948 |
Mean class 2 : |  6.636374999999997 2.903250000000001 5.639375000000001 2.032250000000003 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 0.026098759999999985 -0.01157192000000001 |
|  -0.01924767999999999 0.11199610999999994 -0.007550520000000006 0.005738839999999999 |
|  0.026098759999999985 -0.007550520000000006 0.15171663999999996 0.014833120000000005 |
|  -0.01157192000000001 0.005738839999999999 0.014833120000000005 0.03876896000000001 |

Confusion matrix
| 0 0 |
| 1 19 |

correct 95 %
error 5 %
--------------------------------
```

```
---------- Validation 7 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 4.2156 1.2948 |
Mean class 2 : |  6.599874999999997 2.902000000000001 5.626500000000002 2.0653750000000004 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 0.026098759999999985 -0.01157192000000001 |
|  -0.01924767999999999 0.11199610999999994 -0.007550520000000006 0.005738839999999999 |
|  0.026098759999999985 -0.007550520000000006 0.15171663999999996 0.014833120000000005 |
|  -0.01157192000000001 0.005738839999999999 0.014833120000000005 0.03876896000000001 |

Confusion matrix
| 0 0 |
| 0 20 |

correct 100 %
error 0 %
--------------------------------

---------- Validation 8 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 4.2156 1.2948 |
Mean class 2 : |  6.571874999999997 2.8836250000000003 5.617500000000015 2.043 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 0.026098759999999985 -0.01157192000000001 |
|  -0.01924767999999999 0.11199610999999994 -0.007550520000000006 0.005738839999999999 |
|  0.026098759999999985 -0.007550520000000006 0.15171663999999996 0.014833120000000005 |
|  -0.01157192000000001 0.005738839999999999 0.014833120000000005 0.03876896000000001 |

Confusion matrix
| 0 0 |
| 0 20 |

correct 100 %
error 0 %
--------------------------------

---------- Validation 9 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 4.2156 1.2948 |
Mean class 2 : |  6.605249999999998 2.9152499999999995 5.615375000000001 2.0576250000000003 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 0.026098759999999985 -0.01157192000000001 |
|  -0.01924767999999999 0.11199610999999994 -0.007550520000000006 0.005738839999999999 |
|  0.026098759999999985 -0.007550520000000006 0.15171663999999996 0.014833120000000005 |
|  -0.01157192000000001 0.005738839999999999 0.014833120000000005 0.03876896000000001 |

Confusion matrix
| 0 0 |
| 0 20 |

correct 100 %
error 0 %
--------------------------------
```

```
---------- Validation 10 --------------
Mean class 1 : |  6.350399999999999 2.9216999999999986 4.2156 1.2948 |
Mean class 2 : |  6.593625 2.9083750000000004 5.619749999999998 2.076749999999999 |

Covariance matrices
|  0.3041698400000001 -0.01924767999999999 0.026098759999999985 -0.0115719200000001 |
|  -0.01924767999999999 0.11199610999999994 -0.007550520000000006 0.005738839999999999 |
|  0.026098759999999985 -0.007550520000000006 0.15171663999999996 0.014833120000000005 |
|  -0.0115719200000001 0.005738839999999999 0.014833120000000005 0.03876896000000001 |

Confusion matrix
| 0 0 |
| 2 18 |

correct 90 %
error 10 %
--------------------------------
```

4. สรุปผลการทดลอง

จำนวณ feature ที่นำมาคำนวณ มีผลกับการเลือก class จากผลการทดลอง จะเห็นได้ว่า เมื่อใช้ 2 feature จะมีโอกาสเลือก class ผิดพลาดสูงกว่า ใช้ 4 feature มาก

ภาคผนวก

Code: NodeJS

```
let fs = require('fs')
const math = require('mathjs')

let input = fs.readFileSync('TWOCLASS.dat', 'utf8')
const fNum = 4 //Change number of features here
const percentValidate = 10
const pw1 = 1
const pw2 = 1

const fetchData = Promise.resolve(
    input.trim().split('\r\n').map(x => x.split('\t'))
)

const setUpTestData = (percentValidate, data) => {
    const testDataNum = data.length / percentValidate
    const round = data.length / testDataNum
    let testDatas = []
    for (i = 0; i < round; i++) {
        testDatas.push(data.slice((i * testDataNum), (i * testDataNum +
testDataNum)))
    }
    return testDatas
}

const setUpTrainData = (percentValidate, data) => {
    const testDataNum = data.length / percentValidate
    const round = data.length / testDataNum
    let trainDatas = []
    for (i = 0; i < round; i++) {
        let trainData = []
        for (j = 0; j < data.length; j++) {
            if (j < (i * testDataNum) || j >= (i * testDataNum + testDataNum))
{
                trainData.push(data[j])
            }
        }
        trainDatas.push(trainData)
    }
    return trainDatas
}

const separateClass = (dataSource, classLabel, f) => {
    return dataSource.filter((data) => { return data[4] === classLabel
}).map((val) => {
        return val.slice(0, f)
```

```
    })
}

const average = datas => {
    let initP = []
    initP = datas[0].map(a => 0)
    return datas.reduce((p, c) => {
        let res = []
        for (let i = 0; i < p.length; i++) {
            res.push(parseFloat(p[i]) + parseFloat(c[i]))
        }
        return res
    }, initP).map((sum) => {
        return sum / datas.length
    })
}

const xMinusMean = (datas, means) => {
    return datas.map((data) => {
        let res = []
        for (let i = 0; i < data.length; i++) {
            res.push(parseFloat(data[i]) - parseFloat(means[i]))
        }
        return res
    })
}

const fx = (numClass, cov, xMinusMean) => {
    return (1 / (Math.sqrt(((2 * Math.PI) ^ numClass) * (math.det(cov))))) *
math.exp(math.multiply(math.multiply(math.multiply(math.transpose(xMinusMean),
-0.5), math.inv(cov)), xMinusMean))
}

const main = async () => {
    let sourceData = await fetchData.then((value) => {
        value.shift()
        return value
    })
    const testDatas = setUpTestData(percentValidate, sourceData)
    const trainDatas = setUpTrainData(percentValidate, sourceData)
    for (i = 0; i <= 9; i++) {
        let testData = testDatas[i].map((val) => {
            return val.slice(0, fNum)
        })
        let testClass = testDatas[i].map((val) => {
            return val.slice(-1)
        })
```

```
        let trainClass1 = separateClass(trainDatas[i], '1', fNum)
        let trainClass2 = separateClass(trainDatas[i], '2', fNum)

        let meanClass1 = average(trainClass1)
        let meanClass2 = average(trainClass2)

        let trainXMinusMean1 = xMinusMean(trainClass1, meanClass1)
        let trainXMinusMean2 = xMinusMean(trainClass2, meanClass2)

        let cov1 =
math.multiply(math.multiply(math.transpose(trainXMinusMean1),
trainXMinusMean1), (1 / trainClass1.length))
        let cov2 =
math.multiply(math.multiply(math.transpose(trainXMinusMean2),
trainXMinusMean2), (1 / trainClass2.length))
        let a = 0, b = 0, c = 0, d = 0
        for (j = 0; j < testData.length; j++) {
            let testXMinusMean1 = xMinusMean(testData, meanClass1)
            let testXMinusMean2 = xMinusMean(testData, meanClass2)
            let classChoose
            let fx1 = fx(2, cov1, testXMinusMean1[j])
            let fx2 = fx(2, cov2, testXMinusMean2[j])
            if (fx1 * pw1 === fx2 * pw2) { classChoose =
Math.floor((Math.random() * 2) + 1) }
            else if (fx1 * pw1 > fx2 * pw2) { classChoose = 1 }
            else if (fx1 * pw1 < fx2 * pw2) { classChoose = 2 }

            if (parseInt(testClass[j]) === 1 && classChoose === 1) { a = a + 1
}
            else if (parseInt(testClass[j]) === 1 && classChoose === 2) { b =
b + 1 }
            else if (parseInt(testClass[j]) === 2 && classChoose === 1) { c =
c + 1 }
            else if (parseInt(testClass[j]) === 2 && classChoose === 2) { d =
d + 1 }
        }
        console.log(`---------- Validation ${i + 1} --------------`)
        let smeanClass1 = meanClass1.reduce((res, mean) => res + ' ' + mean,
'')
        let smeanClass2 = meanClass2.reduce((res, mean) => res + ' ' + mean,
'')
        console.log(`Mean class 1 : | ${smeanClass1} |`)
        console.log(`Mean class 2 : | ${smeanClass2} |`)
        console.log(`\nCovariance matrices`)

        cov1.forEach((row) => {
            let cov = row.reduce((res, r) => res + ' ' + r, '')
            console.log(`| ${cov} |`)
```

```
        })
        console.log(`\nConfusion matrix`)
        console.log(`| ${a} ${b} |`)
        console.log(`| ${c} ${d} |`)
        let correct = 100 * (a + d) / (a + b + c + d)
        let error = 100 - correct
        console.log(`\ncorrect ${correct} %`)
        console.log(`error ${error} %`)
        console.log(`-------------------------------\n`)
    }
}

main()
```