北京大学

高级地理信息系统程序作业

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目录

1.作业要求和完成情况

本次程序设计作业的具体要求和完成情况见表 1-1，其中功能部分红色表示作业要求之外的功能。

表 1-1 作业要求及完成情况

项目	功能	完成情况
格网模型	格网生成（两种插值算法）	✓
	格网加密	✓
	显示或者不显示格网	✓
	查询交点属性值	✓
	自动生成等值线（光滑和不光滑两种）	✓
TIN 模型	生成点集凸包	✓
	生成 TIN	✓
	自动生成等值线（光滑和不光滑两种）	✓
拓扑	自动生成	✓
	多边形查询	✓
	拓扑表保存	✓

本次作业采用 C#编写，开发平台为 Visual Studio 2013，运行环境为.Net Frame 3.5 及以上，作业所要求的功能全部实现，经测试符合要求。

2.结果展示

2.1 打开数据

实验数据打开情况如图 2.1 所示。

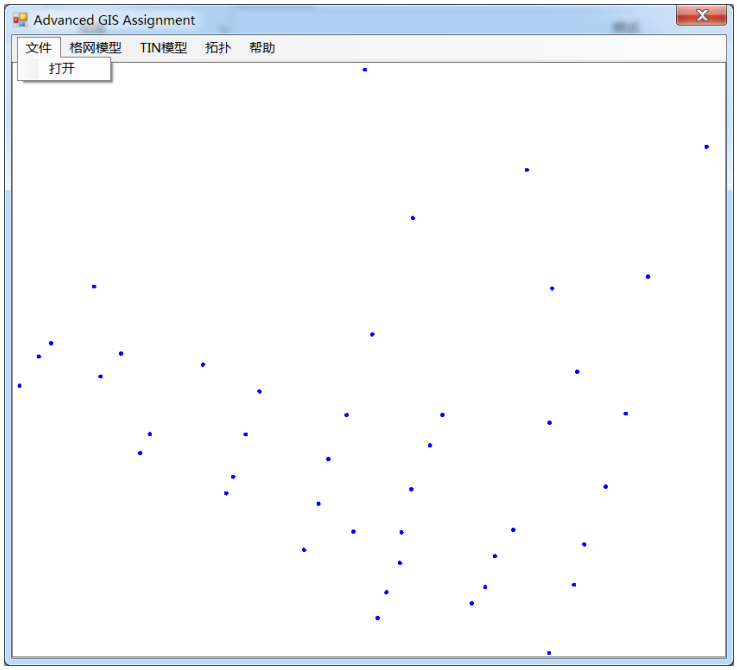


图 2.1 实验数据

2.2 生成格网

生成格网的界面和结果如图 2.2 所示。

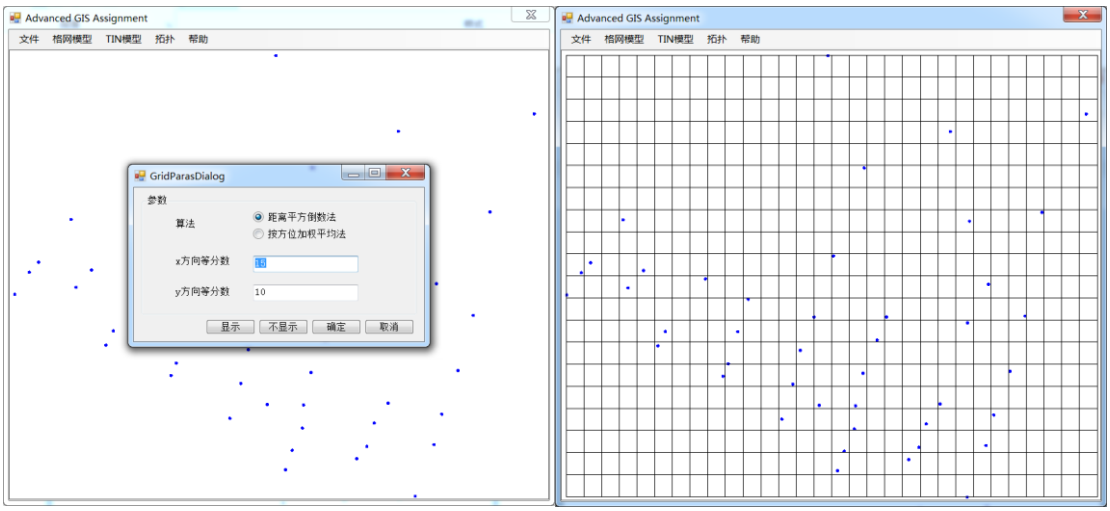


图 2.2 生成格网

2.3 加密格网

加密格网的界面和结果如图 2.3 所示。

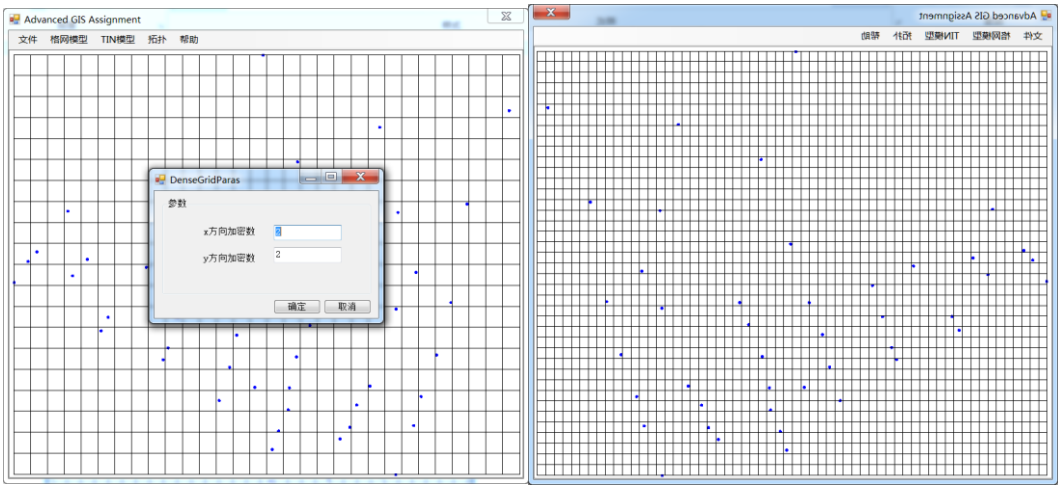


图 2.3 加密格网

2.4 查询格网交点属性值

点击格网交点，查询格网交点的属性，结果如图 2.4 所示。

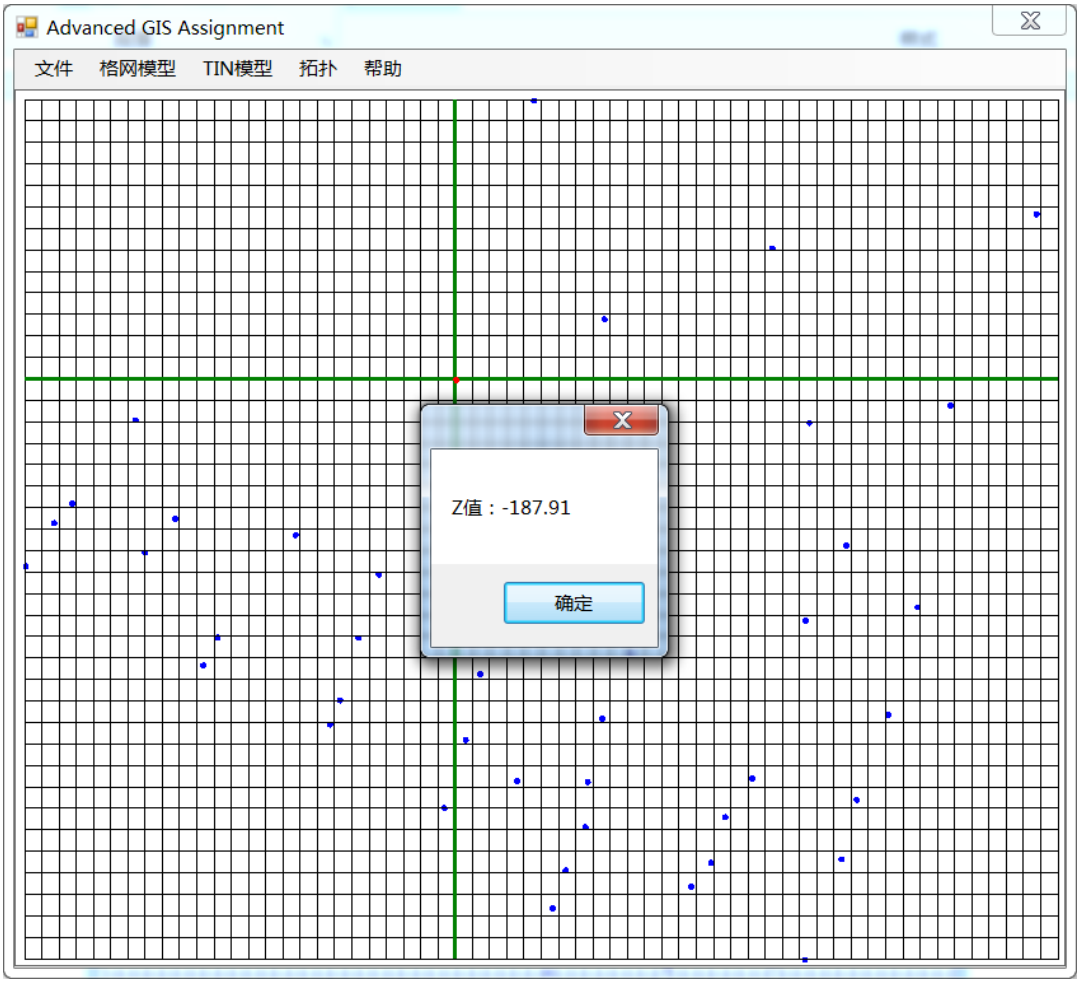
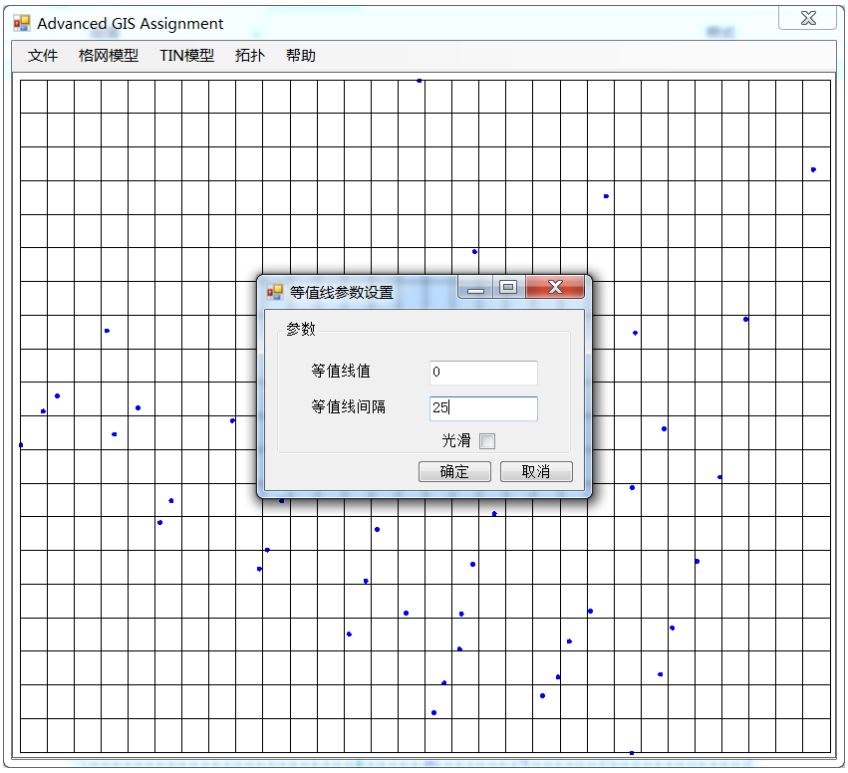


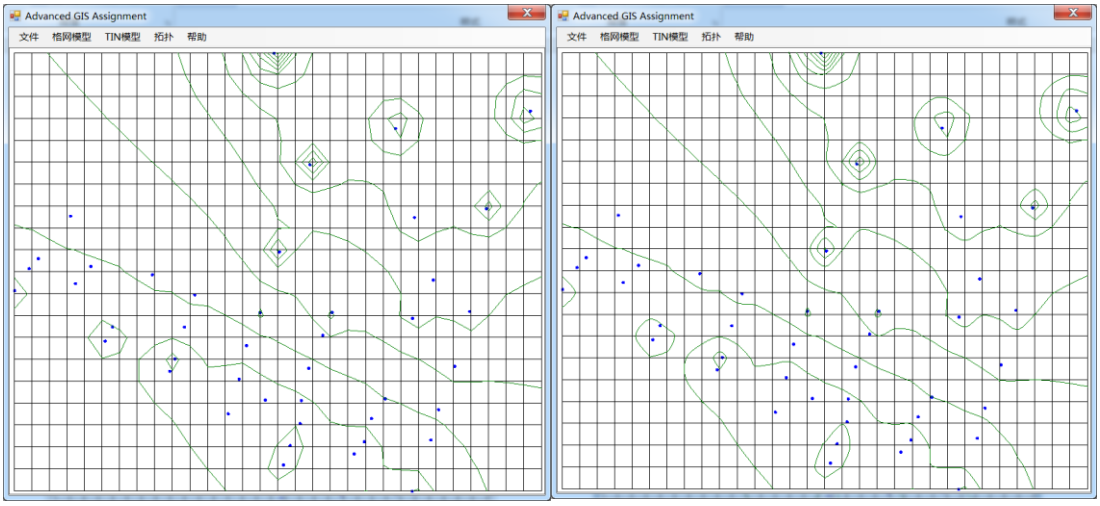
图 2.4 查询交点属性

2.5 根据格网生成等值线

根据格网生成等值线的参数设置和生成结果如图 2.5 和 2.6 所示。



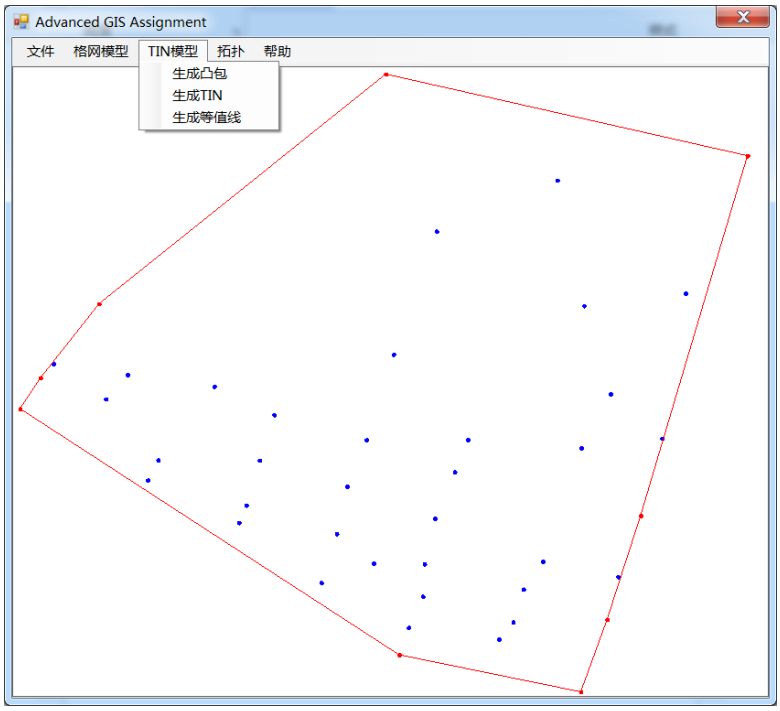
2.5 由格网生成等值线



2.6 格网等值线生成结果（光滑和不光滑）

2.6 生成点集凸包

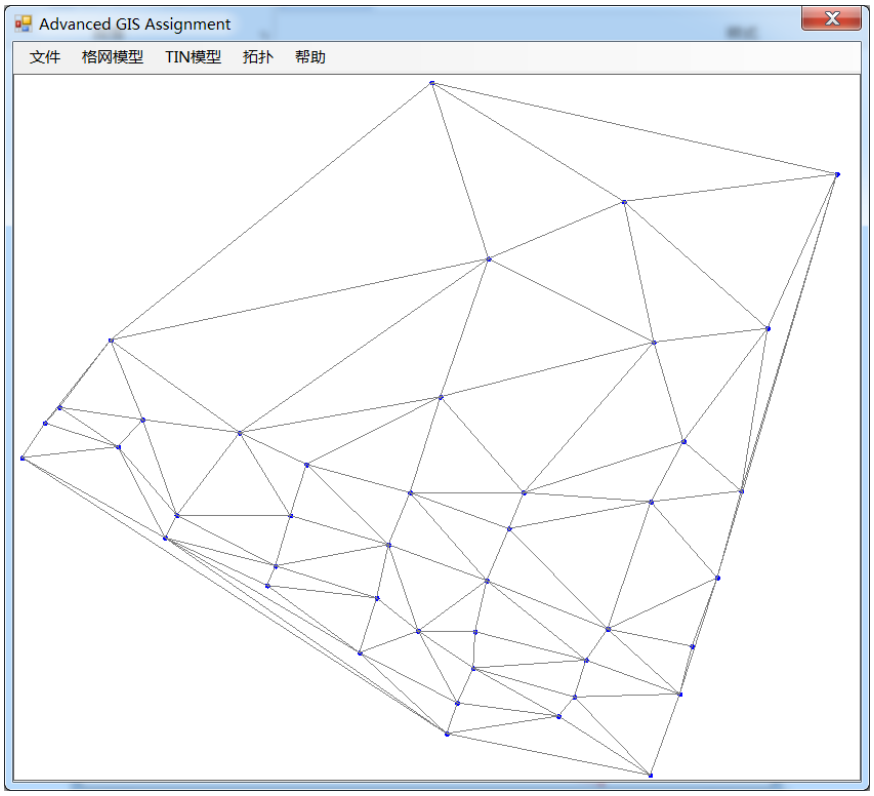
点集的凸包生成结果如图 2.7 所示。



2.7 点集凸包生成结果

2.7 生成 TIN

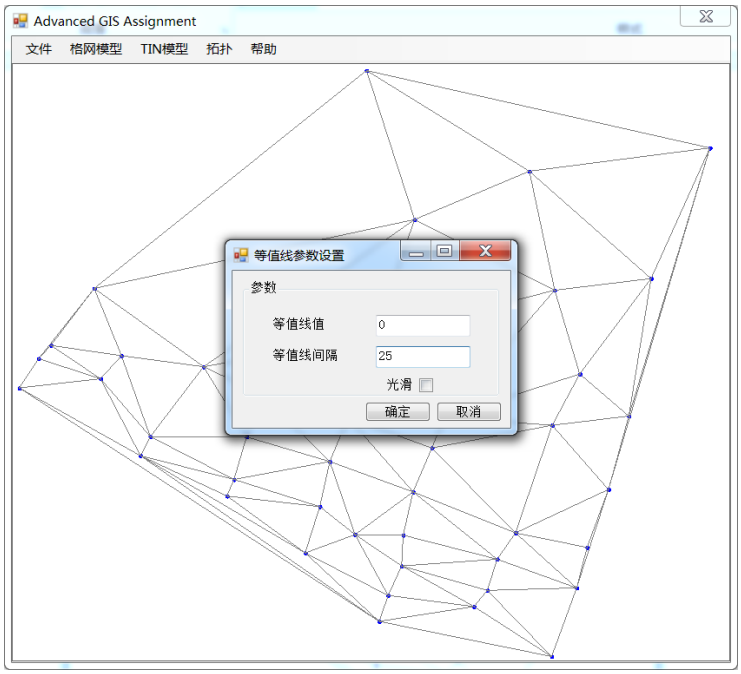
点集的 TIN 生成结果如图 2.8 所示。



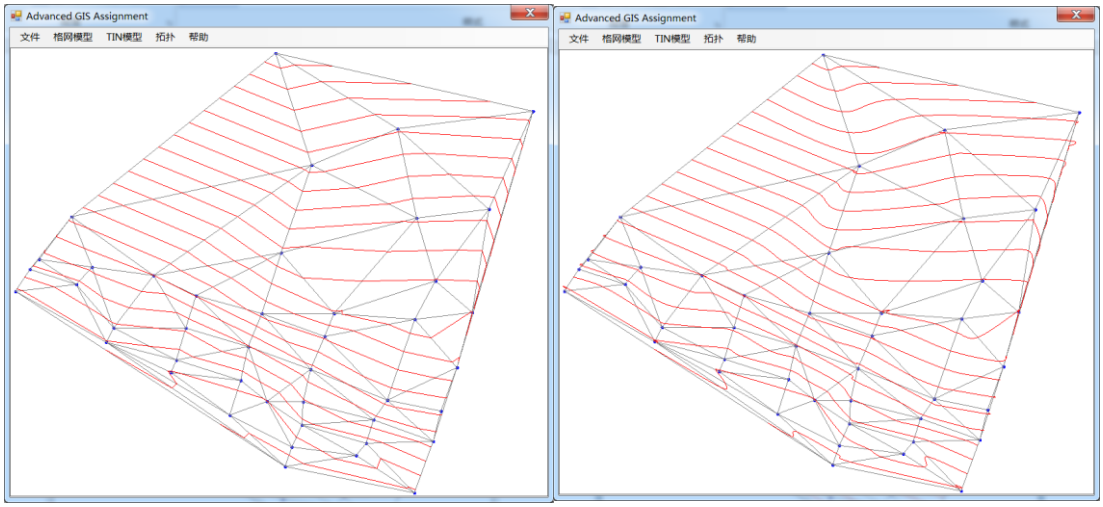
2.8 TIN 生成结果

2.8 由 TIN 生成等值线

根据 TIN 模型生成等值线的参数设置和生成结果如图 2.9 和 2.10 所示。



2.9 由 TIN 生成等值线



2.10 生成 TIN 等值线结果（光滑和不光滑）

2.9 生成拓扑

根据点集的外包矩形边界、外包矩形的对角线、各对边中点连线和格网生成的等值线自动生成拓扑如图 2.11 所示。

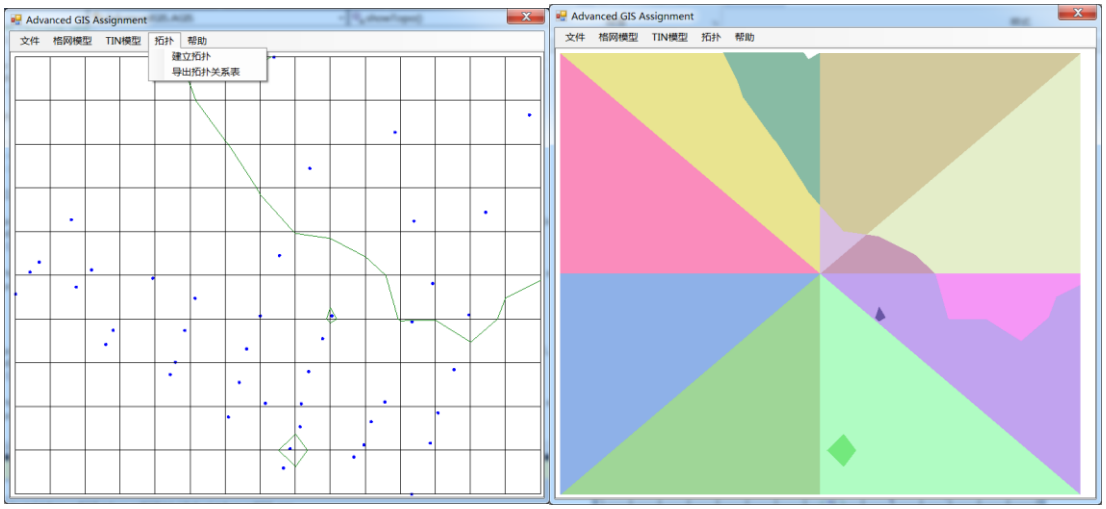


图 2.11 生成拓扑

2.10 查询多边形信息

根据生成的拓扑，查询生成的多边形的属性信息。用鼠标点击要查询的多边形，多边形的信息如图 2.12 所示。

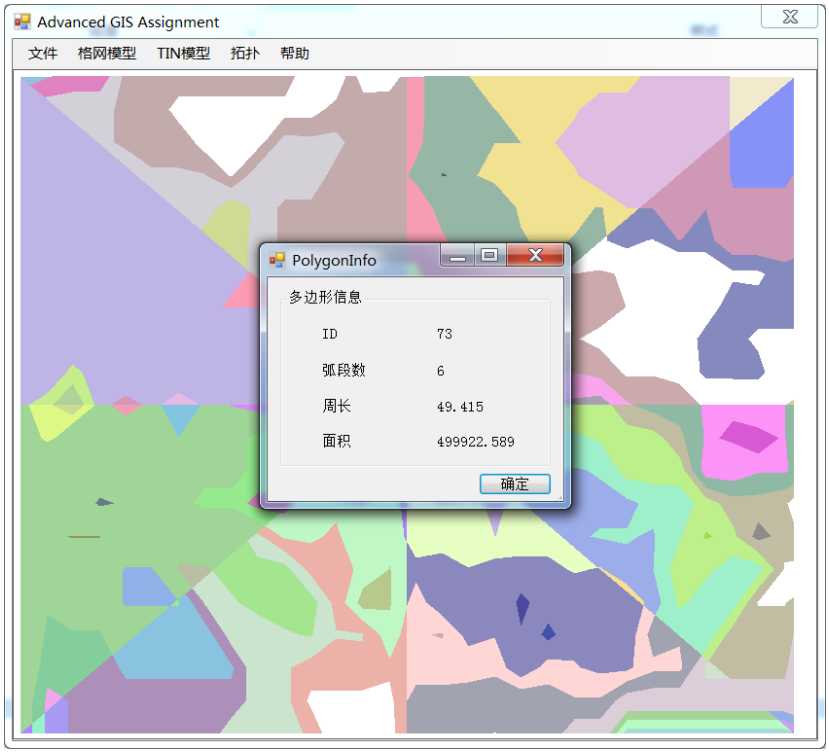


图 2.12 查询多边形信息

2.11 查看并保存拓扑关系表

查看生成的拓扑关系表并保存成文本文件，如图 2.13 和 2.14 所示。

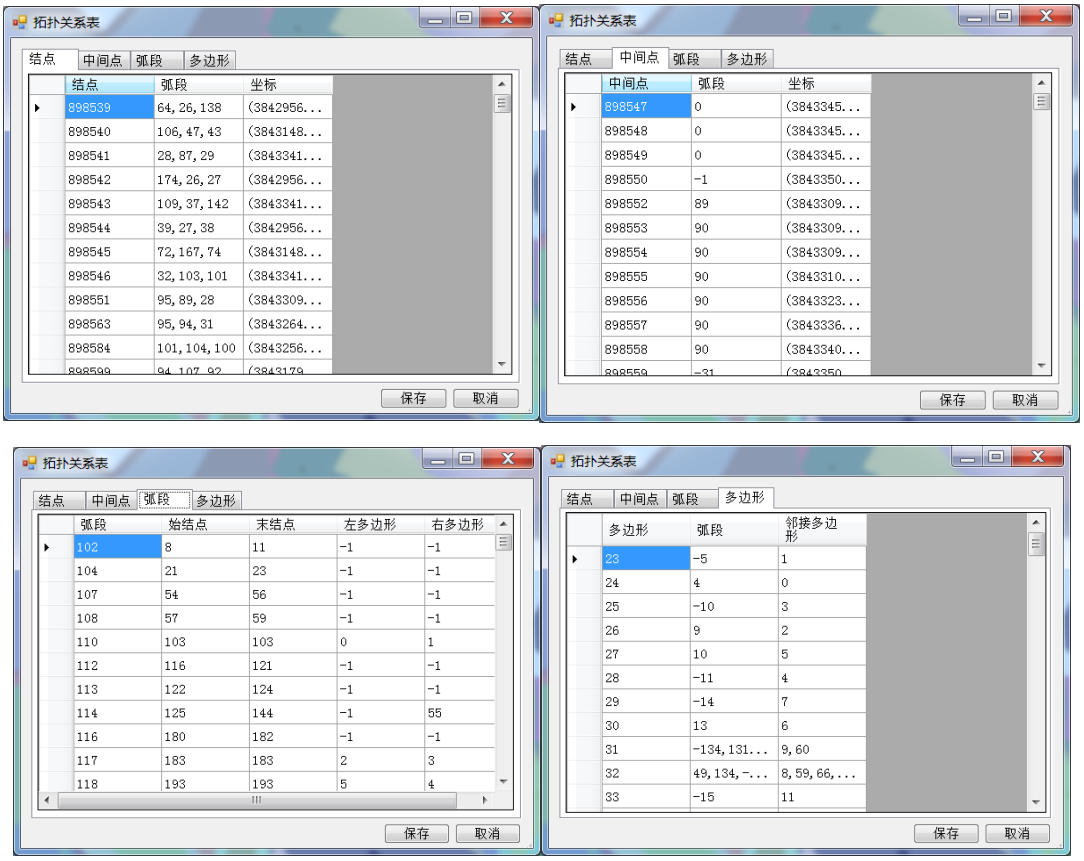


图 2.13 拓扑关系表

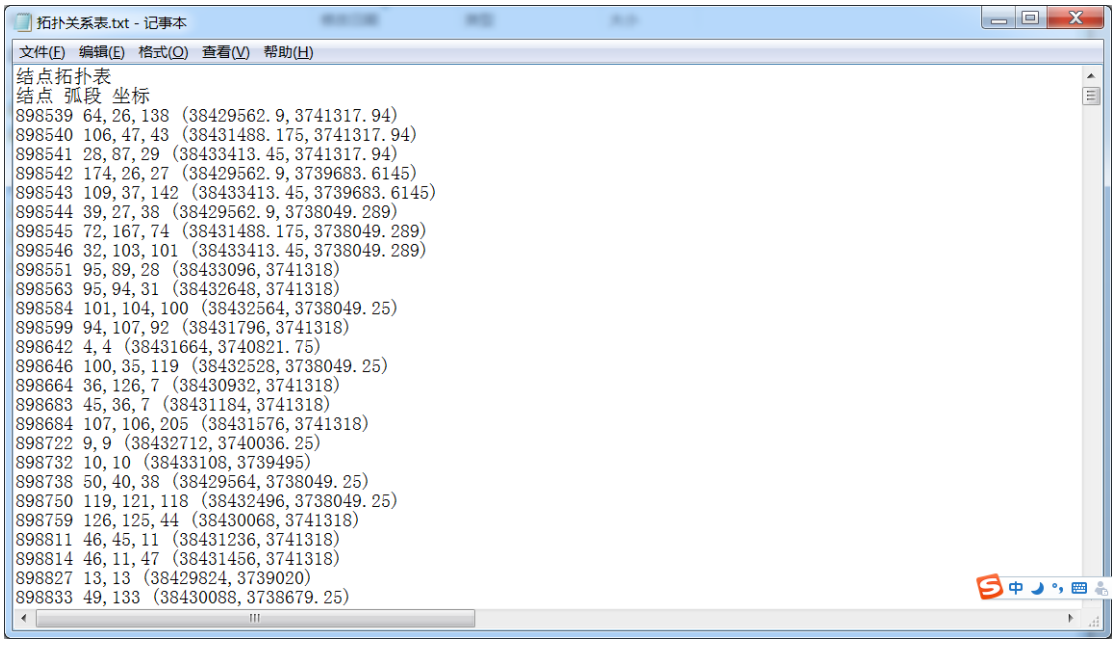


图 2.14 拓扑关系表保存成文本文件

3.代码展示

3.1 距离平方倒数法插值

距离平方倒数法插值的代码如下所示。

```
/// <summary>
///  距离平方倒数法插值
/// </summary>
/// <param name="x">插值点屏幕横坐标</param>
/// <param name="y">插值点屏幕纵坐标</param>
/// <returns>插值点预测的属性值</returns>
private double GetAttributes0(double x,double y)
{
    double wSum = 0,sum=0;
    double xo = (x - margin) * scale + minx;//待插值位置横坐标
    double yo = (pictureBox1.Height-y - margin) * scale + miny;//待插值位置纵坐标
    for (int i = 0; i < data.Count;i++ )
    {
        double reciprocal = 1 / Math.Sqrt((data[i].getX() - xo) * (data[i].getX() - xo) +
(data[i].getY() - yo) * (data[i].getY() - yo));
        wSum += reciprocal;
        sum += data[i].getZ() * reciprocal;
    }
    double preVal = sum / wSum;
    return preVal;
}
```

3.2 按方位加权平均法插值

按方位加权平均法插值的代码如下所示。

```
/// <summary>
///  按方位加权平均法插值
/// </summary>
/// <param name="x0">插值点屏幕横坐标</param>
/// <param name="y0">插值点屏幕纵坐标</param>
/// <returns>插值点属性预测值</returns>
private double GetAttributes1(double x0,double y0)
{
    double x = (x0 - margin) * scale + minx;//插值点位置横坐标
    double y = (pictureBox1.Height - y0 - margin) * scale + miny;//插值点位置纵坐标
```

```
        double preValue = 0, wSum = 0;
        List<int> index = new List<int>();
        List<double> minDis = new List<double>();
        for (int i = 0; i < 8;i++ )//对八个方位，分别找离插值点最近的点
        {
            int tt1 = -1;
            double tt2 = double.MaxValue;
            for(int j=0;j<data.Count;j++)
            {
                double alpha=calAlpha(new MyPoint(x,y),new
MyPoint(data[j].getX(),data[j].getY()));
                if(alpha>=i*45&&alpha<(i+1)*45)
                {
                    if(Math.Sqrt((x-data[j].getY())*(x-data[j].getY())+(y-data[j].getY())*(y-
data[j].getY()))<tt2)
                    {
                        tt1 = j;
                        tt2 = Math.Sqrt((x - data[j].getY()) * (x - data[j].getY()) + (y -
data[j].getY()) * (y - data[j].getY()));
                    }
                }
            }
            if(tt1>=0)
            {
                index.Add(tt1);
                minDis.Add(tt2);
            }
        }
        for (int i = 0; i < index.Count; i++)//计算插值结果
        {
            double wTemp = 1;
            for (int j = 0; j < minDis.Count; j++)
            {
                if (j != i)
                    wTemp *= minDis[j] * minDis[j];
            }
            wSum += wTemp;
            preValue += data[index[i]].getZ() * wTemp;
        }
        preValue = preValue / wSum;
        return preValue;
    }
```

3.3 格网自动生成等值线

网格自动生成等值线的代码如下所示。

```
/// <summary>
///  网格自动生成等值线
/// </summary>
/// <param name="val">等值线的初始值</param>
/// <param name="IsoInterval">等值线间隔</param>
/// <param name="isSmooth">等值线是否光滑</param>
public void generateIsoLineGrid(double val,double IsoInterval,bool isSmooth)
{
    resGrid.Clear();
    //计算 H 矩阵
    double[,] H = new double[xPaceC + 1, yPaceC + 1];
    double xinterval = (pictureBox1.Width - 2 * margin) / xPaceC;
    double yinterval = (pictureBox1.Height - 2 * margin) / yPaceC;
    double HMax = double.MinValue, HMin = double.MaxValue;
    for (int i = 0; i < xPaceC + 1; i++)
    {
        for (int j = 0; j < yPaceC + 1; j++)
        {
            if (methodC == 0)
                H[i, j] = GetAttributes0(margin + xinterval * i, pictureBox1.Height - (margin
+ yinterval * j));
            else
                H[i, j] = GetAttributes1(margin + xinterval * i, pictureBox1.Height - (margin
+ yinterval * j));
            if (HMax < H[i, j])
                HMax = H[i, j];
            if (HMin > H[i, j])
                HMin = H[i, j];
        }
    }
    //找到位于插值区域内的等值线最小值
    if(val>HMax)
    {
        if ((int)((val - HMax) / IsoInterval) == (int)((val - HMin) / IsoInterval) && (int)((val -
HMax) / IsoInterval) != (val - HMax) / IsoInterval)
            return;
        else
        {
            while(val>HMin)
            {
```

```
                    val = val - IsoInterval;
                }
                val = val + IsoInterval;
            }
        }
        else if(val<HMin)
        {
            if ((int)((HMin - val) / IsoInterval) == (int)((HMax - val) / IsoInterval) && (int)((HMin
- val) / IsoInterval) != (HMin - val) / IsoInterval)
                return;
            else
            {
                while (val < HMin)
                    val = val + IsoInterval;
            }
        }
        else
        {
            while(val>HMin)
                val = val -    IsoInterval;
            val = val + IsoInterval;
        }

        for(double HZ=val;HZ<=HMax;HZ=HZ+IsoInterval)//对位于插值区域内的每个值进行插
值
        {
            //对等值线的值 HZ，计算 HH
            double[,] HH = new double[xPaceC, yPaceC+1];
            for (int i = 0; i < xPaceC; i++)
            {
                for (int j = 0; j < yPaceC+1; j++)
                {
                    HH[i, j] = (HZ - H[i, j]) / (H[i+1, j] - H[i, j]);
                    if (HH[i, j] < 0 || HH[i, j] > 1)
                        HH[i, j] = 2;
                    if (H[i, j] == 0)
                        H[i, j] = 0.0001;
                    if (H[i, j] == 1)
                        H[i, j] = 0.9999;
                }
            }
            //对等值线的值 HZ，计算 SS
            double[,] SS = new double[xPaceC+1, yPaceC];
            for (int i = 0; i < xPaceC+1; i++)
```

```
{
    for (int j = 0; j < yPaceC; j++)
    {
        SS[i, j] = (HZ - H[i, j]) / (H[i, j+1] - H[i, j]);
        if (SS[i, j] < 0 || SS[i, j] > 1)
            SS[i, j] = 2;
        if (SS[i, j] == 0)
            SS[i, j] = 0.0001;
        if (SS[i, j] == 1)
            SS[i, j] = 0.9999;
    }
}
for (int i = 0; i < xPaceC; i++)//底边界找线头
{
    if (HH[i, 0] >= 0 && HH[i, 0] <= 1)
    {
        PointF A = new PointF((float)(i + 0.1), -1);
        PointF B = new PointF((float)(i + HH[i, 0]), 0);
        resGrid.Add(GetOneIsoline(A, B, H, SS, HH));
    }
}
for (int i = 0; i < yPaceC; i++)//左边界找线头
{
    if(SS[0,i]>=0&&SS[0,i]<=1)
    {
        PointF A = new PointF(-1,(float)(i + 0.1));
        PointF B = new PointF(0, (float)(i + SS[0, i]));
        resGrid.Add(GetOneIsoline(A, B, H, SS, HH));
    }
}
for (int i = 0; i < xPaceC; i++)//顶边界找线头
{
    if (HH[i, yPaceC] >= 0 && HH[i, yPaceC] <= 1)
    {
        PointF A = new PointF((float)(i + 0.1), yPaceC + 1);
        PointF B = new PointF((float)(i + HH[i, yPaceC]), yPaceC);
        resGrid.Add(GetOneIsoline(A, B, H, SS, HH));
    }
}
for (int i = 0; i < yPaceC; i++)//右边界找线头
{
    if(SS[xPaceC,i]>=0&&SS[xPaceC,i]<=1)
    {
        PointF A = new PointF(xPaceC+1, (float)(i + 0.1));
```

```
                    PointF B = new PointF(xPaceC, (float)(i + SS[xPaceC, i]));
                    resGrid.Add(GetOneIsoline(A, B, H, SS, HH));
                }
            }
            //找闭合等值线，纵边上找线头
            for(int i=1;i<xPaceC;i++)
            {
                for(int j=0;j<yPaceC;j++)
                {
                    if(SS[i,j]>=0&&SS[i,j]<=1)
                    {
                        PointF A = new PointF(i-1, (float)(j + 0.1));
                        PointF B = new PointF(i, (float)(j + SS[i,j]));
                        resGrid.Add(GetOneIsoline(A, B, H, SS, HH));
                    }
                }
            }
        }
        //绘制等值线
        Graphics g = pictureBox1.CreateGraphics();
        Pen myPen=new Pen(Color.Green);
        foreach(List<PointF> lp in resGrid)
        {
            PointF[] temp = new PointF[lp.Count];
            for (int i = 0; i < lp.Count; i++)
            {
                PointF tmp2 = new PointF((float)((lp[i].X - minx) / scale + margin),
(float)(pictureBox1.Height - margin - (lp[i].Y - miny) / scale));
                temp[i] = tmp2;
            }
            if (isSmooth)//画光滑等值线
                g.DrawCurve(myPen, temp);
            else//画不光滑等值线
                g.DrawLines(myPen, temp);
        }
        myPen.Dispose();
        g.Dispose();
        return;
    }
```

追踪一条等值线的代码如下所示。

```
/// <summary>
///  根据初始线头在格网中追踪一条等值线
/// </summary>
/// <param name="AA">初始假想点，确定初始追踪方向</param>
/// <param name="BB">线头</param>
/// <param name="H">H 矩阵</param>
/// <param name="SS">SS 矩阵</param>
/// <param name="HH">HH 矩阵</param>
/// <returns>一条等值线</returns>
public List<PointF> GetOneIsoline(PointF AA,PointF BB,double[,]H,double[,] SS,double[,]HH)
{
    double xinterval = (pictureBox1.Width - 2 * margin) / xPaceC;
    double yinterval = (pictureBox1.Height - 2 * margin) / yPaceC;
    List<PointF> isol = new List<PointF>();
    PointF A = AA;
    PointF B = BB;
    isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y * yinterval * scale + miny)));
    //开始追踪
    while (((int)A.Y < (int)B.Y && B.Y < yPaceC) || ((int)A.X < (int)B.X && B.X < xPaceC) || ((int)A.Y >= (int)B.Y && (int)A.X >= (int)B.X && (int)B.X < B.X && B.Y > 0) || ((int)A.Y >= (int)B.Y && (int)A.X >= (int)B.X && (int)B.Y < B.Y && B.X > 0))//追踪没有达到格网边界
    {
        if ((int)A.Y < (int)B.Y)//自下向上追踪
        {
            if (SS[(int)B.X, (int)B.Y] >= 0 && SS[(int)B.X, (int)B.Y] <= 1)//左边有点
            {
                if (SS[(int)B.X + 1, (int)B.Y] >= 0 && SS[(int)B.X + 1, (int)B.Y] <= 1)//三边都有点
                {
                    double disL = Math.Sqrt(((B.X - (int)B.X) * xinterval) * ((B.X - (int)B.X) * xinterval) + yinterval * yinterval * SS[(int)B.X, (int)B.Y] * SS[(int)B.X, (int)B.Y]);
                    double disR = Math.Sqrt(((1 + (int)B.X - B.X) * xinterval) * ((1 + (int)B.X - B.X) * xinterval) + SS[(int)B.X + 1, (int)B.Y] * yinterval * SS[(int)B.X + 1, (int)B.Y] * yinterval);
                    if (disL > disR)//判断距离左右的距离
                    {
                        PointF tt = new PointF((int)B.X + 1, (float)(B.Y + SS[(int)B.X + 1, (int)B.Y]));
                        A = B;
                        B = tt;
                        isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y * yinterval * scale + miny)));
```

```
                        HH[(int)A.X, (int)A.Y] = 2;
                        continue;
                    }
                    else
                    {
                        PointF tt = new PointF((int)B.X, (float)(B.Y + SS[(int)B.X,
(int)B.Y]));
                        A = B;
                        B = tt;
                        isol.Add(new PointF((float)(B.X * xinterval * scale + minx),
(float)(B.Y * yinterval * scale + miny)));
                        HH[(int)A.X, (int)A.Y] = 2;
                        continue;
                    }
                }
                else//只有左边有点
                {
                    PointF tt = new PointF((int)B.X, (float)(B.Y + SS[(int)B.X, (int)B.Y]));
                    A = B;
                    B = tt;
                    isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y
* yinterval * scale + miny)));
                    HH[(int)A.X, (int)A.Y] = 2;
                    continue;
                }
            }
            if (SS[(int)B.X + 1, (int)B.Y] >= 0 && SS[(int)B.X + 1, (int)B.Y] <= 1)//只有右边
有点
            {
                PointF tt = new PointF((int)B.X + 1, (float)(B.Y + SS[(int)B.X + 1,
(int)B.Y]));
                A = B;
                B = tt;
                isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                HH[(int)A.X, (int)A.Y] = 2;
                continue;
            }
            if (HH[(int)B.X, (int)B.Y + 1] >= 0 && HH[(int)B.X, (int)B.Y + 1] <= 1)//只有右
边有点
            {
                PointF tt = new PointF((int)B.X + (float)HH[(int)B.X, (int)B.Y + 1], (int)B.Y
+ 1);
                A = B;
```

```
                    B = tt;
                    isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                    HH[(int)A.X, (int)A.Y] = 2;
                    continue;
                }
            }
            if ((int)A.X < (int)B.X)//从左向右追踪
            {
                if (HH[(int)B.X, (int)B.Y + 1] >= 0 && HH[(int)B.X, (int)B.Y + 1]<=1)//上边有
点
                {
                    if(HH[(int)B.X,(int)B.Y]>=0&&HH[(int)B.X,(int)B.Y]<=1)//三边都有点
                    {
                        double disd = Math.Sqrt(((B.Y - (int)B.Y) * yinterval) * ((B.Y - (int)B.Y)
* yinterval) + xinterval * xinterval * HH[(int)B.X,(int)B.Y] * HH[(int)B.X,(int)B.Y]);
                        double disu = Math.Sqrt(((1 + (int)B.Y - B.Y) * yinterval) * ((1 +
(int)B.Y - B.Y) * yinterval) + HH[(int)B.X, (int)B.Y + 1] * xinterval * HH[(int)B.X, (int)B.Y + 1]
* xinterval);
                        if (disd > disu)//判断上下边的距离
                        {
                            PointF tt = new PointF((float)(B.X + HH[(int)B.X, (int)B.Y + 1]),
(int)B.Y + 1);
                            A = B;
                            B = tt;
                            isol.Add(new PointF((float)(B.X * xinterval * scale + minx),
(float)(B.Y * yinterval * scale + miny)));
                            SS[(int)A.X, (int)A.Y] = 2;
                            continue;
                        }
                        else
                        {
                            PointF tt = new PointF((float)(B.X + HH[(int)B.X, (int)B.Y]),
(int)B.Y);
                            A = B;
                            B = tt;
                            isol.Add(new PointF((float)(B.X * xinterval * scale + minx),
(float)(B.Y * yinterval * scale + miny)));
                            SS[(int)A.X, (int)A.Y] = 2;
                            continue;
                        }
                    }
                    else//只有上边有点
                    {
```

```
                    PointF tt = new PointF((float)(B.X + HH[(int)B.X, (int)B.Y + 1]),
(int)B.Y + 1);
                    A = B;
                    B = tt;
                    isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y
* yinterval * scale + miny)));
                    SS[(int)A.X, (int)A.Y] = 2;
                    continue;
                }
            }
            if(HH[(int)B.X,(int)B.Y]>=0&&HH[(int)B.X,(int)B.Y]<=1)//只有下边有点
            {
                PointF tt = new PointF((float)(B.X + HH[(int)B.X, (int)B.Y]), (int)B.Y);
                A = B;
                B = tt;
                isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                SS[(int)A.X, (int)A.Y] = 2;
                continue;
            }
            if(SS[(int)B.X+1,(int)B.Y]>=0&&SS[(int)B.X+1,(int)B.Y]<=1)//只有右边有点
            {
                PointF tt = new PointF((float)(B.X + 1), (int)B.Y + (float)SS[(int)B.X + 1,
(int)B.Y]);
                A = B;
                B = tt;
                isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                SS[(int)A.X, (int)A.Y] = 2;
                continue;
            }

        }
        if ((int)B.X < B.X)//自上向下追踪
        {
            if (SS[(int)B.X, (int)B.Y - 1] >= 0 && SS[(int)B.X, (int)B.Y - 1]<=1)//左边有点
            {
                if(SS[(int)B.X+1,(int)B.Y-1]>=0&&SS[(int)B.X+1,(int)B.Y-1]<=1)//三边都
有点
                {
                    double disL = Math.Sqrt(((B.X - (int)B.X) * xinterval) * ((B.X -
(int)B.X) * xinterval) + yinterval * yinterval * (1 - SS[(int)B.X, (int)B.Y - 1]) * (1 - SS[(int)B.X,
(int)B.Y - 1]));
                    double disR = Math.Sqrt(((1 + (int)B.X - B.X) * xinterval) * ((1 +
```

```
(int)B.X - B.X) * xinterval) + (1 - SS[(int)B.X + 1, (int)B.Y - 1]) * yinterval * (1 - SS[(int)B.X +
1, (int)B.Y - 1]) * yinterval);
                        if (disL > disR)//判断连左边还是右边
                        {
                            PointF tt = new PointF((int)B.X + 1, (float)(B.Y-1 + SS[(int)B.X +
1, (int)B.Y-1]));
                            A = B;
                            B = tt;
                            isol.Add(new PointF((float)(B.X * xinterval * scale + minx),
(float)(B.Y * yinterval * scale + miny)));
                            HH[(int)A.X, (int)A.Y] = 2;
                            continue;
                        }
                        else
                        {
                            PointF tt = new PointF((int)B.X, (float)(B.Y-1 + SS[(int)B.X,
(int)B.Y-1]));
                            A = B;
                            B = tt;
                            isol.Add(new PointF((float)(B.X * xinterval * scale + minx),
(float)(B.Y * yinterval * scale + miny)));
                            HH[(int)A.X, (int)A.Y] = 2;
                            continue;
                        }
                    }
                    else//只有左边有点
                    {
                        PointF tt = new PointF((int)B.X, (float)(B.Y - 1 + SS[(int)B.X, (int)B.Y -
1]));
                        A = B;
                        B = tt;
                        isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y
* yinterval * scale + miny)));
                        HH[(int)A.X, (int)A.Y] = 2;
                        continue;
                    }
                }
                if (SS[(int)B.X + 1, (int)B.Y - 1] >= 0 && SS[(int)B.X + 1, (int)B.Y - 1] <= 1)//只
有右边有点
                {
                    PointF tt = new PointF((int)B.X + 1, (float)(B.Y - 1 + SS[(int)B.X + 1,
(int)B.Y - 1]));
                    A = B;
                    B = tt;
```

```
                    isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                    HH[(int)A.X, (int)A.Y] = 2;
                    continue;
                }
                if(HH[(int)B.X,(int)B.Y-1]>=0&&HH[(int)B.X,(int)B.Y-1]<=1)//只有下边有点
                {
                    PointF tt = new PointF((int)B.X + (float)HH[(int)B.X, (int)B.Y - 1],
(float)(B.Y - 1));
                    A = B;
                    B = tt;
                    isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                    HH[(int)A.X, (int)A.Y] = 2;
                    continue;
                }
            }
            if ((int)B.Y < B.Y)//自右向左追踪
            {
                if (HH[(int)B.X - 1, (int)B.Y + 1] >= 0 && HH[(int)B.X - 1, (int)B.Y + 1]<=1)//上
边有点
                {
                    if(HH[(int)B.X-1,(int)B.Y]>=0&&HH[(int)B.X-1,(int)B.Y]<=1)//三边都有点
                    {
                        double disd = Math.Sqrt(((B.Y - (int)B.Y) * yinterval) * ((B.Y - (int)B.Y)
* yinterval) + xinterval * xinterval * (1 - HH[(int)B.X - 1, (int)B.Y]) * (1 - HH[(int)B.X - 1,
(int)B.Y]));
                        double disu = Math.Sqrt(((1 + (int)B.Y - B.Y) * yinterval) * ((1 +
(int)B.Y - B.Y) * yinterval) + (1 - HH[(int)B.X - 1, (int)B.Y + 1]) * xinterval * (1 - HH[(int)B.X -
1, (int)B.Y + 1]) * xinterval);
                        if (disd > disu)//判断该连上边还是下边
                        {
                            PointF tt = new PointF((float)(B.X-1 + HH[(int)B.X-1, (int)B.Y +
1]), (int)B.Y + 1);
                            A = B;
                            B = tt;
                            isol.Add(new PointF((float)(B.X * xinterval * scale + minx),
(float)(B.Y * yinterval * scale + miny)));
                            SS[(int)A.X, (int)A.Y] = 2;
                            continue;
                        }
                        else
                        {
                            PointF tt = new PointF((float)(B.X - 1 + HH[(int)B.X - 1,
```

```
(int)B.Y]), (int)B.Y);
                                A = B;
                                B = tt;
                                isol.Add(new PointF((float)(B.X * xinterval * scale + minx),
(float)(B.Y * yinterval * scale + miny)));
                                SS[(int)A.X, (int)A.Y] = 2;
                                continue;
                            }
                        }
                        else//只有上边有点
                        {
                            PointF tt = new PointF((float)(B.X - 1 + HH[(int)B.X - 1, (int)B.Y + 1]),
(int)B.Y + 1);
                            A = B;
                            B = tt;
                            isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y
* yinterval * scale + miny)));
                            SS[(int)A.X, (int)A.Y] = 2;
                            continue;
                        }
                    }
                    if (HH[(int)B.X - 1, (int)B.Y] >= 0 && HH[(int)B.X - 1, (int)B.Y] <= 1)//只有下
边有点
                    {
                        PointF tt = new PointF((float)(B.X - 1 + HH[(int)B.X - 1, (int)B.Y]),
(int)B.Y);
                        A = B;
                        B = tt;
                        isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                        SS[(int)A.X, (int)A.Y] = 2;
                        continue;
                    }
                    if (SS[(int)B.X - 1, (int)B.Y] >= 0 && SS[(int)B.X - 1, (int)B.Y]<=1)//只有左边
有点
                    {
                        PointF tt = new PointF((float)(B.X - 1), (int)B.Y + (float)SS[(int)B.X - 1,
(int)B.Y]);
                        A = B;
                        B = tt;
                        isol.Add(new PointF((float)(B.X * xinterval * scale + minx), (float)(B.Y *
yinterval * scale + miny)));
                        SS[(int)A.X, (int)A.Y] = 2;
                        continue;
```

```
                }
            }
            //如果四种情况都不是，说明是闭曲线，加入开始的起点，追踪完毕
            isol.Add(new PointF(isol[0].X,isol[0].Y));
            break;
        }
        //追踪的最后一段曲线的 HH 或者 SS 矩阵赋值为 2
        if(B.X-(int)B.X==0)
            SS[(int)B.X,(int)B.Y]=2;
        else
            HH[(int)B.X, (int)B.Y] = 2;
        return isol;
}
```

3.4 生成点集凸包

生成点集凸包的代码如下所示。

```
/// <summary>
///  根据点集生成凸包，Graham's Scan 算法
/// </summary>
/// <param name="od">点集</param>
/// <returns>凸包点序列</returns>
public static List<int> generateConvex(List<Dt> od)
{
    List<int> res = new List<int>();
    List<double> tmp1 = new List<double>();
    List<int> tmp2 = new List<int>();
    //找到最低点的序号
    int minYIndex=0;
    for (int i = 0; i < od.Count;i++ )
    {
        if (od[i].getY() < od[minYIndex].getY() || (od[i].getY() == od[minYIndex].getY() &&
od[i].getX() < od[minYIndex].getX()))
            minYIndex = i;
    }
    tmp1.Add(-1);
    tmp2.Add(minYIndex);
    //将所有点按照和最低点构成的向量的角度从大到小排列
    for (int i = 0; i < od.Count;i++ )
    {
        if(i!=minYIndex)
        {
            double cos = (od[i].getX() - od[minYIndex].getX()) / Math.Sqrt((od[i].getX() -
```

```
od[minYIndex].getX()) * (od[i].getX() - od[minYIndex].getX()) + (od[i].getY() - od[minYIndex].getY()) * (od[i].getY() - od[minYIndex].getY()));
                int j;
                for(j=0;j<tmp1.Count;j++)
                {
                    if(cos<tmp1[j])
                    {
                        tmp1.Insert(j,cos);
                        tmp2.Insert(j,i);
                        break;
                    }
                }
                if(j==tmp1.Count)
                {
                    tmp1.Add(cos);
                    tmp2.Add(i);
                }
            }
        }
        //开始追踪凸包多边形
        res.Add(tmp2[0]);
        res.Add(tmp2[1]);
        for (int i = 2; i < tmp2.Count;i++ )
        {
            //计算两个向量的叉积
            double s = (od[res[res.Count - 1]].getX() - od[res[res.Count - 2]].getX()) * (od[tmp2[i]].getY() - od[res[res.Count - 1]].getY()) - (od[res[res.Count - 1]].getY() - od[res[res.Count - 2]].getY()) * (od[tmp2[i]].getX() - od[res[res.Count - 1]].getX());
            while(s>0)//叉积大于零，需要删去之前的点
            {
                res.RemoveAt(res.Count - 1);
                s = (od[res[res.Count - 1]].getX() - od[res[res.Count - 2]].getX()) * (od[tmp2[i]].getY() - od[res[res.Count - 1]].getY()) - (od[res[res.Count - 1]].getY() - od[res[res.Count - 2]].getY()) * (od[tmp2[i]].getX() - od[res[res.Count - 1]].getX());
            }
            res.Add(tmp2[i]);
        }
        return res;
    }
```

3.5 生成点集 TIN 模型

根据点集生成 TIN 模型的代码如下所示。

```
/// <summary>
///  生长法生成 TIN
/// </summary>
/// <param name="data">原始点集</param>
/// <param name="convex">点集凸包</param>
/// <param name="arcList">TIN 的边的列表</param>
/// <param name="TINConvex">边描述的 TIN 凸包</param>
/// <param name="res">TIN 三角网</param>
public static void generateTIN(List<Dt> data, List<int> convex, List<Arc> arcList, List<int>
TINConvex, List<AdvancedGIS.dataStructure.Triangle> res)
{
    res.Clear();
    arcList.Clear();
    TINConvex.Clear();
    List<int> queue = new List<int>();//边的队列
    Arc at = new dataStructure.Arc(0, convex[0] > convex[1] ? convex[1] : convex[0],
convex[0] > convex[1] ? convex[0] : convex[1], 0);
    at.po=true;
    at.po = zhengfuqu(at,data,data[convex[convex.Count-1]]);
    arcList.Add(at);
    queue.Add(0);//加入初始生长边
    while(queue.Count>0)//队列不空，继续生长
    {
        double tmpCos=double.MaxValue;
        int ind=-1;
        for(int i=0;i<data.Count;i++)//求位于当前生长边一侧的张角最大的点的序号
        {
            if (i != arcList[queue[0]].startPoint && i != arcList[queue[0]].endPoint &&
zhengfuqu(arcList[queue[0]],data,data[i]))
            {
                double tt=COS(data[arcList[queue[0]].startPoint],
data[arcList[queue[0]].endPoint],data[i]);
                if (tt < tmpCos)
                {
                    tmpCos = tt;
                    ind = i;
                }
            }
        }
        if(ind<0)//在追踪边一侧未找到点，删除此边
        {
            arcList[queue[0]].useTimes++;
            queue.RemoveAt(0);
            continue;
```

```
}
//找到了点，则向队列里新加两边，得到一个三角形
arcList[queue[0]].useTimes++;
int sp=arcList[queue[0]].startPoint > ind ? ind : arcList[queue[0]].startPoint;
int ep=arcList[queue[0]].startPoint > ind ? arcList[queue[0]].startPoint:ind;
int k1;
for(k1=0;k1<arcList.Count;k1++)
{
    if (arcList[k1].startPoint == sp && arcList[k1].endPoint == ep)
    {
        arcList[k1].useTimes++;
        break;
    }
}
if (k1 == arcList.Count)
{
    at = new AdvancedGIS.dataStructure.Arc(arcList.Count, sp, ep, 1);
    at.po=false;
    at.po = zhengfuqu(at, data, data[arcList[queue[0]].endPoint]);
    arcList.Add(at);
}

sp = arcList[queue[0]].endPoint > ind ? ind : arcList[queue[0]].endPoint;
ep = arcList[queue[0]].endPoint > ind ? arcList[queue[0]].endPoint : ind;
int k2;
for (k2 = 0; k2 < arcList.Count; k2++)
{
    if (arcList[k2].startPoint == sp && arcList[k2].endPoint == ep)
    {
        arcList[k2].useTimes++;
        break;
    }
}
if (k2 == arcList.Count)
{
    at = new AdvancedGIS.dataStructure.Arc(arcList.Count, sp, ep, 1);
    at.po = false;
    at.po = zhengfuqu(at,data,data[arcList[queue[0]].startPoint]);
    arcList.Add(at);
}

int[] tmpID = new int[3];
tmpID[0]= queue[0];
tmpID[1] = k1;
```

```
            tmpID[2] = k2;
            for(int i=0;i<tmpID.Length-1;i++)
            {
                for(int j=i+1;j<tmpID.Length;j++)
                {
                    if(tmpID[i]>tmpID[j])
                    {
                        int ttt = tmpID[i];
                        tmpID[i] = tmpID[j];
                        tmpID[j] = ttt;
                    }
                }
            }
            Triangle tmpTri = new
AdvancedGIS.dataStructure.Triangle(arcList[queue[0]].startPoint, arcList[queue[0]].endPoint,
ind);
            tmpTri.arcID1 = tmpID[0];
            tmpTri.arcID2 = tmpID[1];
            tmpTri.arcID3 = tmpID[2];
            int kk;
            for (kk = 0; kk < res.Count;kk++ )
            {
                if (res[kk].arcID1 == tmpTri.arcID1 && res[kk].arcID2 == tmpTri.arcID2 &&
res[kk].arcID3 == tmpTri.arcID3)
                    break;
            }
            if (kk == res.Count)
                res.Add(tmpTri);
            if (arcList[k1].useTimes < 2)
                queue.Add(k1);
            if (arcList[k2].useTimes < 2)
                queue.Add(k2);
            queue.RemoveAt(0);
        }
        //三角网生成结束，下面生成拓扑关系
        //给边加入三角形信息
        for(int i=0;i<res.Count;i++)
        {
            if (arcList[res[i].arcID1].tri[0] == -1)
                arcList[res[i].arcID1].tri[0] = i;
            else if (arcList[res[i].arcID1].tri[1] == -1)
                arcList[res[i].arcID1].tri[1] = i;
            if (arcList[res[i].arcID2].tri[0] == -1)
                arcList[res[i].arcID2].tri[0] = i;
```

```
            else if (arcList[res[i].arcID2].tri[1] == -1)
                arcList[res[i].arcID2].tri[1] = i;
            if (arcList[res[i].arcID3].tri[0] == -1)
                arcList[res[i].arcID3].tri[0] = i;
            else if (arcList[res[i].arcID3].tri[1] == -1)
                arcList[res[i].arcID3].tri[1] = i;
        }
        //生成以边为基础的点集凸包
        for (int i = 0; i < convex.Count;i++)
        {
            int minPP = convex[i] > convex[(i + 1) % convex.Count] ? convex[(i + 1) %
convex.Count] : convex[i];
            int maxPP = convex[i] <= convex[(i + 1) % convex.Count] ? convex[(i + 1) %
convex.Count] : convex[i];
            for(int j=0;j<arcList.Count;j++)
            {
                if (minPP == arcList[j].startPoint && maxPP == arcList[j].endPoint)
                    TINConvex.Add(j);
            }
        }
        return;
}
```

正负区判断的代码如下所示。

```
public static bool zhengfuqu(Arc a,List<Dt> data,Dt p3)
{
    if(data[a.startPoint].getX()==data[a.endPoint].getX())
    {
        if (p3.getX() > data[a.startPoint].getX())
            return !a.po;
        else
            return a.po;
    }
    else
    {
        double tmp = (data[a.startPoint].getY() - data[a.endPoint].getY()) /
(data[a.startPoint].getX() - data[a.endPoint].getX()) * (p3.getX() - data[a.endPoint].getX()) +
data[a.endPoint].getY();
        return (tmp-p3.getY())> 0 ? (!a.po) : a.po;
    }
}
```

3.6 TIN 自动生成等值线

自动生成并绘制等值线的代码如下所示。

```
/// <summary>
/// TIN 模型生成等值线
/// </summary>
/// <param name="val">等值线起始值</param>
/// <param name="IsoInterval">等值线间隔</param>
/// <param name="isSmooth">是否光滑</param>
public void generateIsoLineTIN(double val, double IsoInterval,bool isSmooth)
{
    List<List<PointF>> res = new List<List<PointF>>();//存储结果
    //计算区域内存在的值最小的等值线
    double HMax = double.MinValue, HMin = double.MaxValue;
    for (int i = 0; i<data.Count; i++)
    {
        if (HMax < data[i].getZ())
            HMax = data[i].getZ();
        if (HMin > data[i].getZ())
            HMin = data[i].getZ();
    }
    if (val > HMax)
    {
        if ((int)((val - HMax) / IsoInterval) == (int)((val - HMin) / IsoInterval) && (int)((val -
HMax) / IsoInterval) != (val - HMax) / IsoInterval)
            return;
        else
        {
            while (val > HMin)
            {
                val = val - IsoInterval;
            }
            val = val + IsoInterval;
        }
    }
    else if (val < HMin)
    {
        if ((int)((HMin - val) / IsoInterval) == (int)((HMax - val) / IsoInterval) && (int)((HMin
- val) / IsoInterval) != (HMin - val) / IsoInterval)
            return;
        else
        {
            while (val < HMin)
```

```
                {
                    val = val + IsoInterval;
                }
            }
        }
        else
        {
            while (val > HMin)
            {
                val = val - IsoInterval;
            }
            val = val + IsoInterval;
        }
        //对每个等值线的值追踪等值线
        for (double HZ = val; HZ <= HMax; HZ = HZ + IsoInterval)
        {
            //计算 HH 矩阵
            double[] HH = new double[triArc.Count];
            for(int i=0;i<triArc.Count;i++)
            {
                HH[i]=(HZ-data[triArc[i].startPoint].getZ())/(data[triArc[i].endPoint].getZ()-
data[triArc[i].startPoint].getZ());
                if(HH[i]==1)
                    HH[i]=0.9999;
                else if(HH[i]==0)
                    HH[i]=0.0001;
                else if(HH[i]>1||HH[i]<0)
                    HH[i]=2;
            }

            //找开曲线线头
            for(int i=0;i<TINConvex.Count;i++)
            {
                if(HH[TINConvex[i]]<=1&&HH[TINConvex[i]]>=0)
                {
                    res.Add(GetOneIsolineTin(TINConvex[i], HH));
                }
            }
            //找闭曲线线头
            for(int i=0;i<triArc.Count;i++)
            {
                if(HH[i]>=0&&HH[i]<=1)
                {
                    res.Add(GetOneIsolineTin(i, HH));
```

```
                }
            }
        }
        //绘制等值线
        Graphics g = pictureBox1.CreateGraphics();
        Pen myPen = new Pen(Color.Red);
        foreach (List<PointF> lp in res)
        {
            PointF[] temp = new PointF[lp.Count];
            for (int i = 0; i < lp.Count; i++)
            {
                PointF tmp2 = new PointF((float)((lp[i].X - minx) / scale + margin),
(float)(pictureBox1.Height - margin - (lp[i].Y - miny) / scale));
                temp[i] = tmp2;
            }
            if (isSmooth)//绘制光滑等值线
                g.DrawCurve(myPen, temp);
            else//不光滑等值线
                g.DrawLines(myPen, temp);
        }
        myPen.Dispose();
        g.Dispose();
        return;
}
```

追踪一条等值线的代码如下所示。

```
/// <summary>
///  根据线头追踪一条等值线
/// </summary>
/// <param name="arcStart">线头</param>
/// <param name="HH">HH 矩阵</param>
/// <returns>追踪的等值线</returns>
public List<PointF> GetOneIsolineTin(int arcStart,double[]HH)
{
        List<PointF> res = new List<PointF>();//存结果
        List<int> queue=new List<int>();//追踪队列
        queue.Add(arcStart);
        res.Add(new
PointF((float)(data[triArc[arcStart].startPoint].getX()+HH[arcStart]*(data[triArc[arcStart].endPoi
nt].getX()-
data[triArc[arcStart].startPoint].getX())),(float)(data[triArc[arcStart].startPoint].getY()+HH[arcSta
rt]*(data[triArc[arcStart].endPoint].getY()-data[triArc[arcStart].startPoint].getY()))));
        HH[arcStart]=2;
        while(queue.Count>0)//追踪队列不空，追踪未结束
```

```
    {
        bool ischanged=false;
        //找边所在的三角形
        if(triArc[queue[0]].tri[0]!=-1)
        {
            Triangle tmpT=TINRes[triArc[queue[0]].tri[0]];
            //分别找三角形三边是否存在当前点。若有则加入等值线，，所在边加入队列
            if(HH[tmpT.arcID1]>=0&&HH[tmpT.arcID1]<=1)
            {
                queue.Add(tmpT.arcID1);
                res.Add(new PointF((float)(data[triArc[tmpT.arcID1].startPoint].getX() +
HH[tmpT.arcID1] * (data[triArc[tmpT.arcID1].endPoint].getX() -
data[triArc[tmpT.arcID1].startPoint].getX())), (float)(data[triArc[tmpT.arcID1].startPoint].getY()
+ HH[tmpT.arcID1] * (data[triArc[tmpT.arcID1].endPoint].getY() -
data[triArc[tmpT.arcID1].startPoint].getY())));
                HH[tmpT.arcID1] = 2;
                ischanged=true;
            }
            else if (HH[tmpT.arcID2] >= 0 && HH[tmpT.arcID2] <= 1)
            {
                queue.Add(tmpT.arcID2);
                res.Add(new PointF((float)(data[triArc[tmpT.arcID2].startPoint].getX() +
HH[tmpT.arcID2] * (data[triArc[tmpT.arcID2].endPoint].getX() -
data[triArc[tmpT.arcID2].startPoint].getX())), (float)(data[triArc[tmpT.arcID2].startPoint].getY()
+ HH[tmpT.arcID2] * (data[triArc[tmpT.arcID2].endPoint].getY() -
data[triArc[tmpT.arcID2].startPoint].getY())));
                HH[tmpT.arcID2] = 2;
                ischanged=true;
            }
            else if (HH[tmpT.arcID3] >= 0 && HH[tmpT.arcID3] <= 1)
            {
                queue.Add(tmpT.arcID3);
                res.Add(new PointF((float)(data[triArc[tmpT.arcID3].startPoint].getX() +
HH[tmpT.arcID3] * (data[triArc[tmpT.arcID3].endPoint].getX() -
data[triArc[tmpT.arcID3].startPoint].getX())), (float)(data[triArc[tmpT.arcID3].startPoint].getY()
+ HH[tmpT.arcID3] * (data[triArc[tmpT.arcID3].endPoint].getY() -
data[triArc[tmpT.arcID3].startPoint].getY())));
                HH[tmpT.arcID3] = 2;
                ischanged=true;
            }
        }
        if(triArc[queue[0]].tri[1]!=-1)
        {
            Triangle tmpT = TINRes[triArc[queue[0]].tri[1]];
```

```
                //分别找三角形三边是否存在当前点。若有则加入等值线，，所在边加入队列
                if (HH[tmpT.arcID1] >= 0 && HH[tmpT.arcID1] <= 1)
                {
                    queue.Add(tmpT.arcID1);
                    res.Add(new PointF((float)(data[triArc[tmpT.arcID1].startPoint].getX() +
HH[tmpT.arcID1] * (data[triArc[tmpT.arcID1].endPoint].getX() -
data[triArc[tmpT.arcID1].startPoint].getX())), (float)(data[triArc[tmpT.arcID1].startPoint].getY()
+ HH[tmpT.arcID1] * (data[triArc[tmpT.arcID1].endPoint].getY() -
data[triArc[tmpT.arcID1].startPoint].getY())));
                    HH[tmpT.arcID1] = 2;
                    ischanged=true;
                }
                else if (HH[tmpT.arcID2] >= 0 && HH[tmpT.arcID2] <= 1)
                {
                    queue.Add(tmpT.arcID2);
                    res.Add(new PointF((float)(data[triArc[tmpT.arcID2].startPoint].getX() +
HH[tmpT.arcID2] * (data[triArc[tmpT.arcID2].endPoint].getX() -
data[triArc[tmpT.arcID2].startPoint].getX())), (float)(data[triArc[tmpT.arcID2].startPoint].getY()
+ HH[tmpT.arcID2] * (data[triArc[tmpT.arcID2].endPoint].getY() -
data[triArc[tmpT.arcID2].startPoint].getY())));
                    HH[tmpT.arcID2] = 2;
                    ischanged=true;
                }
                else if (HH[tmpT.arcID3] >= 0 && HH[tmpT.arcID3] <= 1)
                {
                    queue.Add(tmpT.arcID3);
                    res.Add(new PointF((float)(data[triArc[tmpT.arcID3].startPoint].getX() +
HH[tmpT.arcID3] * (data[triArc[tmpT.arcID3].endPoint].getX() -
data[triArc[tmpT.arcID3].startPoint].getX())), (float)(data[triArc[tmpT.arcID3].startPoint].getY()
+ HH[tmpT.arcID3] * (data[triArc[tmpT.arcID3].endPoint].getY() -
data[triArc[tmpT.arcID3].startPoint].getY())));
                    HH[tmpT.arcID3] = 2;
                    ischanged=true;
                }
            }
            if (triArc[queue[0]].tri[1] != -1 && triArc[queue[0]].tri[0] != -1&&ischanged==false)//
闭曲线
            {
                res.Add(new PointF(res[0].X,res[0].Y));
            }
            queue.RemoveAt(0);
        }
        return res;
    }
```

3.7 自动生成拓扑

拓扑生成的代码如下所示。

```
private void  建立拓扑 ToolStripMenuItem_Click(object sender, EventArgs e)
{
    if (gridIsoline == false)
        MessageBox.Show("没有利用格网生成的等值线！");
    gridFlag = false;
    mp.Clear();
    ma.Clear();
    mpol.Clear();
    initData();//初始化基础的点和线
    breakLine();//线之间两两打断
    for(int i = 0; i < ma.Count;i++)//给所有点生成拓扑关系
    {
        mp[ma[i].startPoint].lineNum++;
        mp[ma[i].startPoint].relLine.Add(i);
        mp[ma[i].endPoint].lineNum++;
        mp[ma[i].endPoint].relLine.Add(-i-1);
        for(int j=0;j<ma[i].midPointNum;j++)
        {
            mp[ma[i].midPoint[j]].lineNum++;
            mp[ma[i].midPoint[j]].relLine.Add(i);
        }
    }
    trackPolygon();//追踪多边形并生成拓扑
    showTopo();//显示拓扑生成结果，用不同颜色表示不同多边形
    topo = true;
}

/// <summary>
///  加入原始点和线
/// </summary>
private void initData()
{
    //加入点集外包矩形等的基础数据
    double EnvMaxx = double.MinValue, EnvMinx = double.MaxValue, EnvMaxy =
double.MinValue, EnvMiny = double.MaxValue;
    for (int i = 0; i < data.Count; i++)
    {
        if (EnvMaxx < data[i].getX())
            EnvMaxx = data[i].getX();
        if (EnvMinx > data[i].getX())
```

```
            EnvMinx = data[i].getX();
        if (EnvMaxy < data[i].getY())
            EnvMaxy = data[i].getY();
        if (EnvMiny > data[i].getY())
            EnvMiny = data[i].getY();
}
mp.Add(new MyPoint(EnvMinx, EnvMaxy));
mp.Add(new MyPoint(0.5 * (EnvMinx + EnvMaxx), EnvMaxy));
mp.Add(new MyPoint(EnvMaxx, EnvMaxy));
mp.Add(new MyPoint(EnvMinx, 0.5 * (EnvMaxy + EnvMiny)));
mp.Add(new MyPoint(EnvMaxx, 0.5 * (EnvMaxy + EnvMiny)));
mp.Add(new MyPoint(EnvMinx, EnvMiny));
mp.Add(new MyPoint(0.5 * (EnvMinx + EnvMaxx), EnvMiny));
mp.Add(new MyPoint(EnvMaxx, EnvMiny));

List<int> arctmp = new List<int>();
arctmp.Add(0);
arctmp.Add(2);
ma.Add(new MyArc(arctmp));
arctmp.Clear();
arctmp.Add(0);
arctmp.Add(5);
ma.Add(new MyArc(arctmp));
arctmp.Clear();
arctmp.Add(2);
arctmp.Add(7);
ma.Add(new MyArc(arctmp));
arctmp.Clear();
arctmp.Add(5);
arctmp.Add(7);
ma.Add(new MyArc(arctmp));
arctmp.Clear();
arctmp.Add(0);
arctmp.Add(7);
ma.Add(new MyArc(arctmp));
arctmp.Clear();
arctmp.Add(2);
arctmp.Add(5);
ma.Add(new MyArc(arctmp));
arctmp.Clear();
arctmp.Add(3);
arctmp.Add(4);
ma.Add(new MyArc(arctmp));
arctmp.Clear();
```

```
        arctmp.Add(1);
        arctmp.Add(6);
        ma.Add(new MyArc(arctmp));
        //加入格网生成的等值线的基础数据
        for (int i = 0; i < resGrid.Count; i++)
        {
            arctmp.Clear();
            for (int j = 0; j < resGrid[i].Count - 1; j++)
            {
                arctmp.Add(addOnePointToMP(new MyPoint(resGrid[i][j].X,
resGrid[i][j].Y)));
            }
            if (resGrid[i][resGrid[i].Count - 1].X == resGrid[i][0].X &&
resGrid[i][resGrid[i].Count - 1].Y == resGrid[i][0].Y)
            {
                arctmp.Add(arctmp[0]);
            }
            else
            {
                arctmp.Add(addOnePointToMP(new
MyPoint(resGrid[i][resGrid[i].Count - 1].X, resGrid[i][resGrid[i].Count - 1].Y)));
            }
            ma.Add(new MyArc(arctmp));
        }
}

/// <summary>
///  线段之间两两打断
/// </summary>
private void breakLine()
{
        for (int i = 0; i < ma.Count - 1; i++)
        {
            for (int j = i + 1; j < ma.Count; j++)
            {
                if (ma[i].midPointNum+2 == 2)
                {
                    if (ma[j].midPointNum+2 == 2)
                        j=breakTwoTwo(i, j);//两点线段之间打断
                    else
                        j=breakTwoMore(i, j);//两点和多点
                }
                else
                {
```

```
                    if (ma[j].midPointNum+2 == 2)
                        j = breakTwoMore(j, i);//多点和两点
                    else
                        j=breakMoreMore(i, j);//多点和多点
                }
            }
        }
    }

    private int breakTwoTwo(int i,int j)
    {
        List<int> pArray = new List<int>();
        MyPoint p1 = mp[ma[i].startPoint], p2 = mp[ma[i].endPoint],p3 =
    mp[ma[j].startPoint],p4 = mp[ma[j].endPoint];
        MyPoint tres = CalIntersect(p1, p2, p3, p4);
        if (tres != null)
        {
            if (!isEqual(tres, p1) && !isEqual(tres, p2))
            {
                if (!isEqual(tres, p3) && !isEqual(tres, p4))
                {
                    int indexMP = addOnePointToMP(tres);
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(indexMP);
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(ma[j].startPoint);
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(indexMP);
                    pArray.Add(ma[j].endPoint);
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(j);
                    ma.RemoveAt(i);
                    return i;
                }
                else if (isEqual(tres, p3))
                {
```

```
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(ma[j].startPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                return i;
        }
        else if (isEqual(tres, p4))
        {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].endPoint);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                return i;
        }
}
else if (isEqual(tres, p2))
{
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].endPoint);
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                return j-1;
        }
}
else
{
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
```

```
                {
                    pArray.Clear();
                    pArray.Add(ma[j].startPoint);
                    pArray.Add(ma[i].startPoint);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    pArray.Add(ma[j].endPoint);
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(j);
                    return j - 1;
                }
            }
        }
        return j;
    }

    private int breakTwoMore(int i,int j)
    {
        List<int> pArray = new List<int>();
        MyPoint p1 = mp[ma[i].startPoint], p2 = mp[ma[i].endPoint], p3, p4;
        p3 = mp[ma[j].startPoint];
        p4 = mp[ma[j].midPoint[0]];
        MyPoint tres = CalIntersect(p1, p2, p3, p4);
        if (tres != null)//两点对开头
        {
            if (!isEqual(tres, p1) && !isEqual(tres, p2))
            {
                if (!isEqual(tres, p3) && !isEqual(tres, p4))
                {
                    int indexMP = addOnePointToMP(tres);
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(indexMP);
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(ma[j].startPoint);
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
```

```
                pArray.Add(indexMP);
                for (int k = 0; k < ma[j].midPointNum; k++)
                {
                        pArray.Add(ma[j].midPoint[k]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                if (i < j)
                {
                        ma.RemoveAt(j);
                        ma.RemoveAt(i);
                        return i;
                }
                else
                {
                        ma.RemoveAt(i);
                        ma.RemoveAt(j);
                        return j;
                }
        }
        else if (isEqual(tres, p3))
        {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(ma[j].startPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                if (i < j)
                        return i;
                else
                        return i - 1;
        }
}
else if (isEqual(tres, p1))
{
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].startPoint);
```

```
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    for (int k = 0; k < ma[j].midPointNum; k++)
                    {
                        pArray.Add(ma[j].midPoint[k]);
                    }
                    pArray.Add(ma[j].endPoint);
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(j);
                    if (i < j)
                        return j - 1;
                    else
                        return j;
                }
            }
            else
            {
                if (!isEqual(tres, p3) && !isEqual(tres, p4))
                {
                    pArray.Clear();
                    pArray.Add(ma[j].startPoint);
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(ma[i].endPoint);
                    for (int k = 0; k < ma[j].midPointNum; k++)
                    {
                        pArray.Add(ma[j].midPoint[k]);
                    }
                    pArray.Add(ma[j].endPoint);
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(j);
                    if (i < j)
                        return j - 1;
                    else
                        return j;
                }
            }
        }

        p3 = mp[ma[j].midPoint[ma[j].midPointNum - 1]];
        p4 = mp[ma[j].endPoint];
        tres = CalIntersect(p1, p2, p3, p4);
```

```
if (tres != null)//两点与后面
{
    if (!isEqual(tres, p1) && !isEqual(tres, p2))
    {
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
            int indexMP = addOnePointToMP(tres);
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int k = 0; k < ma[j].midPointNum; k++)
            {
                pArray.Add(ma[j].midPoint[k]);
            }
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            if (i < j)
            {
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else
            {
                ma.RemoveAt(i);
                ma.RemoveAt(j);
                return j;
            }
        }
        else if (isEqual(tres, p3))
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
```

```
            pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int k = 0; k < ma[j].midPointNum; k++)
            {
                pArray.Add(ma[j].midPoint[k]);
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            if (i < j)
            {
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else
            {
                ma.RemoveAt(i);
                ma.RemoveAt(j);
                return j;
            }
        }
        else
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].endPoint);
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(i);
            if (i < j)
                return i;
            else
```

```
                return i - 1;
        }
    }
    else if (isEqual(tres, p1))
    {
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int k = 0; k < ma[j].midPointNum; k++)
            {
                pArray.Add(ma[j].midPoint[k]);
            }
            pArray.Add(ma[i].startPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            if (i < j)
                return j - 1;
            else
                return j;
        }
        else if (isEqual(tres, p3))
        {
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int k = 0; k < ma[j].midPointNum; k++)
                pArray.Add(ma[j].midPoint[k]);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            if (i < j)
                return j - 1;
            else
                return j;
        }
    }
    else
```

```
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int k = 0; k < ma[j].midPointNum; k++)
                {
                    pArray.Add(ma[j].midPoint[k]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].endPoint);
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                if (i < j)
                    return j - 1;
                else
                    return j;
            }
            else if (isEqual(tres, p3))
            {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int k = 0; k < ma[j].midPointNum; k++)
                    pArray.Add(ma[j].midPoint[k]);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                if (i < j)
                    return j - 1;
                else
                    return j;
            }
        }
    }
    //两个点和中间
    for (int s = 0; s < ma[j].midPointNum - 1; s++)
    {
        p3 = mp[ma[j].midPoint[s]];
```

```
p4 = mp[ma[j].midPoint[s + 1]];
tres = CalIntersect(p1, p2, p3, p4);
if (tres != null)
{
    if (!isEqual(tres, p1) && !isEqual(tres, p2))
    {
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
            int indexMP = addOnePointToMP(tres);
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int k = 0; k < s + 1; k++)
            {
                pArray.Add(ma[j].midPoint[k]);
            }
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            for (int k = s + 1; k < ma[j].midPointNum; k++)
            {
                pArray.Add(ma[j].midPoint[k]);
            }
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            if (i < j)
            {
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else
            {
                ma.RemoveAt(i);
                ma.RemoveAt(j);
                return j;
```

```
                }
            }
            else if (isEqual(tres, p3))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(ma[j].midPoint[s]);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].midPoint[s]);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int k = 0; k < s + 1; k++)
                {
                    pArray.Add(ma[j].midPoint[k]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int k = s; k < ma[j].midPointNum; k++)
                {
                    pArray.Add(ma[j].midPoint[k]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                if (i < j)
                {
                    ma.RemoveAt(j);
                    ma.RemoveAt(i);
                    return i;
                }
                else
                {
                    ma.RemoveAt(i);
                    ma.RemoveAt(j);
                    return j;
                }
            }
        }
        else if (isEqual(tres, p1))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
```

```
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int k = 0; k < s + 1; k++)
                {
                        pArray.Add(ma[j].midPoint[k]);
                }
                pArray.Add(ma[i].startPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int k = s + 1; k < ma[j].midPointNum; k++)
                {
                        pArray.Add(ma[j].midPoint[k]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                if (i < j)
                        return j - 1;
                else
                        return j;
        }
        else if (isEqual(tres, p3))
        {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int k = 0; k < s + 1; k++)
                        pArray.Add(ma[j].midPoint[k]);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int k = s ; k < ma[j].midPointNum; k++)
                {
                        pArray.Add(ma[j].midPoint[k]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                if (i < j)
                        return j - 1;
                else
                        return j;
        }
}
else
```

```
{
    if (!isEqual(tres, p3) && !isEqual(tres, p4))
    {
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int k = 0; k < s + 1; k++)
        {
            pArray.Add(ma[j].midPoint[k]);
        }
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[i].endPoint);
        for (int k = s + 1; k < ma[j].midPointNum; k++)
        {
            pArray.Add(ma[j].midPoint[k]);
        }
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        if (i < j)
            return j - 1;
        else
            return j;
    }
    else if (isEqual(tres, p3))
    {
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int k = 0; k < s + 1; k++)
        {
            pArray.Add(ma[j].midPoint[k]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        for (int k = s; k < ma[j].midPointNum; k++)
        {
            pArray.Add(ma[j].midPoint[k]);
        }
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        if (i < j)
            return j - 1;
```

```
                        else
                            return j;
                    }
                }
            }
        }
        if(i<j)
            return j;
        else
            return i;
}

//private int breakMoreTwo(int i,int j)
//{
//      return j;
//}
private int breakMoreMore(int i,int j)
{
        List<int> pArray = new List<int>();
        //开头
        MyPoint p1 = mp[ma[i].startPoint], p2 = mp[ma[i].midPoint[0]], p3, p4;
        p3 = mp[ma[j].startPoint];
        p4 = mp[ma[j].midPoint[0]];
        MyPoint tres = CalIntersect(p1, p2, p3, p4);
        if(tres!=null)//开头和开头
        {
            if(!isEqual(tres,p1)&&!isEqual(tres,p2))
            {
                if (!isEqual(tres, p3) && !isEqual(tres, p4))
                {
                    int indexMP = addOnePointToMP(tres);
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(indexMP);
                    for (int s = 0; s < ma[i].midPointNum;s++)
                    {
                        pArray.Add(ma[i].midPoint[s]);
                    }
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
```

```
                pArray.Add(ma[j].startPoint);
                pArray.Add(indexMP);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(indexMP);
                for (int s = 0; s < ma[j].midPointNum; s++)
                {
                    pArray.Add(ma[j].midPoint[s]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else if (isEqual(tres, p3))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(ma[j].startPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int s = 0; s < ma[i].midPointNum; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                return i;
            }
        }
        else if(isEqual(tres,p1))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].startPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int s = 0; s < ma[j].midPointNum; s++)
```

```
                {
                    pArray.Add(ma[j].midPoint[s]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                return j - 1;
            }
        }
    }

    p3 = mp[ma[j].midPoint[ma[j].midPointNum-1]];
    p4 = mp[ma[j].endPoint];
    tres = CalIntersect(p1, p2, p3, p4);
    if (tres != null)//开头和结尾
    {
        if (!isEqual(tres, p1) && !isEqual(tres, p2))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                int indexMP = addOnePointToMP(tres);
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(indexMP);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(indexMP);
                for (int s = 0; s < ma[i].midPointNum; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int s = 0; s < ma[j].midPointNum; s++)
                {
                    pArray.Add(ma[j].midPoint[s]);
                }
                pArray.Add(indexMP);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(indexMP);
                pArray.Add(ma[j].endPoint);
```

```
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            ma.RemoveAt(i);
            return i;
        }
        else if (isEqual(tres, p3))
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
            for (int s = 0; s < ma[i].midPointNum; s++)
            {
                pArray.Add(ma[i].midPoint[s]);
            }
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int s = 0; s < ma[j].midPointNum; s++)
            {
                pArray.Add(ma[j].midPoint[s]);
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[ma[j].midPointNum-1]);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            ma.RemoveAt(i);
            return i;
        }
        else
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].endPoint);
            for (int s = 0; s < ma[i].midPointNum; s++)
            {
```

```
                pArray.Add(ma[i].midPoint[s]);
            }
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(i);
            return i;
        }
    }
    else if (isEqual(tres, p1))
    {
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int s = 0; s < ma[j].midPointNum; s++)
            {
                pArray.Add(ma[j].midPoint[s]);
            }
            pArray.Add(ma[i].startPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            return j - 1;
        }
        else if(isEqual(tres, p3))
        {
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int s = 0; s < ma[j].midPointNum; s++)
            {
                pArray.Add(ma[j].midPoint[s]);
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[ma[j].midPointNum-1]);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            return j - 1;
        }
    }
```

```
}
for (int s = 0; s < ma[j].midPointNum - 1;s++)
{
    p3 = mp[ma[j].midPoint[s]];
    p4 = mp[ma[j].midPoint[s+1]];
    tres = CalIntersect(p1, p2, p3, p4);
    if (tres != null)//开头和中间
    {
        if (!isEqual(tres, p1) && !isEqual(tres, p2))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                int indexMP = addOnePointToMP(tres);
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(indexMP);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(indexMP);
                for (int ss = 0; ss < ma[i].midPointNum; ss++)
                {
                    pArray.Add(ma[i].midPoint[ss]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int ss = 0; ss < s+1; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(indexMP);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(indexMP);
                for (int ss = s+1; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
```

```
            }
            else if(isEqual(tres, p3))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                pArray.Add(ma[j].midPoint[s]);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].midPoint[s]);
                for (int ss = 0; ss < ma[i].midPointNum; ss++)
                {
                    pArray.Add(ma[i].midPoint[ss]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int ss = 0; ss < s + 1; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int ss = s + 1; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
        }
        else if(isEqual(tres, p1))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int ss = 0; ss < s + 1; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
```

```
                        pArray.Add(ma[i].startPoint);
                        ma.Add(new MyArc(pArray));
                        pArray.Clear();
                        pArray.Add(ma[i].startPoint);
                        for (int ss = s + 1; ss < ma[j].midPointNum; ss++)
                        {
                            pArray.Add(ma[j].midPoint[ss]);
                        }
                        pArray.Add(ma[j].endPoint);
                        ma.Add(new MyArc(pArray));
                        ma.RemoveAt(j);
                        return j-1;
                    }
                    else if (isEqual(tres, p3))
                    {
                        pArray.Clear();
                        pArray.Add(ma[j].startPoint);
                        for (int ss = 0; ss < s + 1; ss++)
                        {
                            pArray.Add(ma[j].midPoint[ss]);
                        }
                        ma.Add(new MyArc(pArray));
                        pArray.Clear();
                        for (int ss = s + 1; ss < ma[j].midPointNum; ss++)
                        {
                            pArray.Add(ma[j].midPoint[ss]);
                        }
                        pArray.Add(ma[j].endPoint);
                        ma.Add(new MyArc(pArray));
                        ma.RemoveAt(j);
                        return j - 1;
                    }
                }
            }
        }
        //尾部
        p1 = mp[ma[i].midPoint[ma[i].midPointNum - 1]];
        p2 = mp[ma[i].endPoint];
        p3 = mp[ma[j].startPoint];
        p4 = mp[ma[j].midPoint[0]];
        tres = CalIntersect(p1, p2, p3, p4);
        if (tres != null)//尾部对开头
        {
            if (!isEqual(tres, p1) && !isEqual(tres, p2))
```

```
{
    if (!isEqual(tres, p3) && !isEqual(tres, p4))
    {
        int indexMP = addOnePointToMP(tres);
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int ss = 0; ss < ma[i].midPointNum; ss++)
        {
            pArray.Add(ma[i].midPoint[ss]);
        }
        pArray.Add(indexMP);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(indexMP);
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        pArray.Add(indexMP);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(indexMP);
        for (int ss = 0; ss < ma[j].midPointNum; ss++)
        {
            pArray.Add(ma[j].midPoint[ss]);
        }
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        ma.RemoveAt(i);
        return i;
    }
    else if(isEqual(tres, p3))
    {
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int ss = 0; ss < ma[i].midPointNum; ss++)
        {
            pArray.Add(ma[i].midPoint[ss]);
        }
        pArray.Add(ma[j].startPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
```

```
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                return i;
            }
        }
        else if(isEqual(tres, p1))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int ss = 0; ss < ma[i].midPointNum; ss++)
                {
                    pArray.Add(ma[i].midPoint[ss]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].midPoint[ma[i].midPointNum-1]);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
                for (int ss = 0; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else if (isEqual(tres, p3))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int ss = 0; ss < ma[i].midPointNum; ss++)
                {
                    pArray.Add(ma[i].midPoint[ss]);
```

```
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                return i;
            }
        }
        else
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].endPoint);
                for (int ss = 0; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                return j - 1;
            }
        }
    }
    p3 = mp[ma[j].midPoint[ma[j].midPointNum - 1]];
    p4 = mp[ma[j].endPoint];
    tres = CalIntersect(p1, p2, p3, p4);
    if (tres != null)//尾部和尾部
    {
        if (!isEqual(tres, p1) && !isEqual(tres, p2))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                int indexMP = addOnePointToMP(tres);
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int ss = 0; ss < ma[i].midPointNum; ss++)
```

```
        {
            pArray.Add(ma[i].midPoint[ss]);
        }
        pArray.Add(indexMP);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(indexMP);
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int ss = 0; ss < ma[j].midPointNum; ss++)
        {
            pArray.Add(ma[j].midPoint[ss]);
        }
        pArray.Add(indexMP);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(indexMP);
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        ma.RemoveAt(i);
        return i;
    }
    else if(isEqual(tres,p3))
    {
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int ss = 0; ss < ma[i].midPointNum; ss++)
        {
            pArray.Add(ma[i].midPoint[ss]);
        }
        pArray.Add(ma[j].midPoint[ma[j].midPointNum-1]);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int ss = 0; ss < ma[j].midPointNum; ss++)
        {
            pArray.Add(ma[j].midPoint[ss]);
```

```
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            ma.RemoveAt(i);
            return i;
        }
        else
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            for (int ss = 0; ss < ma[i].midPointNum; ss++)
            {
                pArray.Add(ma[i].midPoint[ss]);
            }
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].endPoint);
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(i);
            return i;
        }
    }
    else if(isEqual(tres,p1))
    {
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            for (int ss = 0; ss < ma[i].midPointNum; ss++)
            {
                pArray.Add(ma[i].midPoint[ss]);
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[i].midPoint[ma[i].midPointNum-1]);
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
```

```
        pArray.Add(ma[j].startPoint);
        for (int ss = 0; ss < ma[j].midPointNum; ss++)
        {
            pArray.Add(ma[j].midPoint[ss]);
        }
        pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        ma.RemoveAt(i);
        return i;
    }
    else if (isEqual(tres, p3))
    {
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int ss = 0; ss < ma[i].midPointNum; ss++)
        {
            pArray.Add(ma[i].midPoint[ss]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int ss = 0; ss < ma[j].midPointNum; ss++)
        {
            pArray.Add(ma[j].midPoint[ss]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        ma.RemoveAt(i);
        return i;
    }
    else
```

```
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            for (int ss = 0; ss < ma[i].midPointNum; ss++)
            {
                pArray.Add(ma[i].midPoint[ss]);
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(i);
            return i;
        }
    }
    else
    {
        if (!isEqual(tres, p3) && !isEqual(tres, p4))
        {
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int ss = 0; ss < ma[j].midPointNum; ss++)
            {
                pArray.Add(ma[j].midPoint[ss]);
            }
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[i].endPoint);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            return j-1;
        }
        else if (isEqual(tres, p3))
        {
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int ss = 0; ss < ma[j].midPointNum; ss++)
            {
                pArray.Add(ma[j].midPoint[ss]);
            }
            ma.Add(new MyArc(pArray));
```

```
                pArray.Clear();
                pArray.Add(ma[j].midPoint[ma[j].midPointNum-1]);
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                return j - 1;
            }
        }
    }
    //后面对中间
    for (int s = 0; s < ma[j].midPointNum - 1; s++)
    {
        p3 = mp[ma[j].midPoint[s]];
        p4 = mp[ma[j].midPoint[s + 1]];
        tres = CalIntersect(p1, p2, p3, p4);
        if (tres != null)
        {
            if (!isEqual(tres, p1) && !isEqual(tres, p2))
            {
                if (!isEqual(tres, p3) && !isEqual(tres, p4))
                {
                    int indexMP = addOnePointToMP(tres);
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    for (int ss = 0; ss < ma[i].midPointNum; ss++)
                    {
                        pArray.Add(ma[i].midPoint[ss]);
                    }
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(indexMP);
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(ma[j].startPoint);
                    for (int ss = 0; ss < s+1; ss++)
                    {
                        pArray.Add(ma[j].midPoint[ss]);
                    }
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(indexMP);
```

```
                for (int ss = s+1; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else if (isEqual(tres, p3))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int ss = 0; ss < ma[i].midPointNum; ss++)
                {
                    pArray.Add(ma[i].midPoint[ss]);
                }
                pArray.Add(ma[j].midPoint[s]);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].midPoint[s]);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int ss = 0; ss < s + 1; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int ss = s; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
        }
        else if(isEqual(tres,p1))
```

```
{
    if (!isEqual(tres, p3) && !isEqual(tres, p4))
    {
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int ss = 0; ss < ma[i].midPointNum; ss++)
        {
            pArray.Add(ma[i].midPoint[ss]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[i].midPoint[ma[i].midPointNum-1]);
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int ss = 0; ss < s + 1; ss++)
        {
            pArray.Add(ma[j].midPoint[ss]);
        }
        pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
        for (int ss = s + 1; ss < ma[j].midPointNum; ss++)
        {
            pArray.Add(ma[j].midPoint[ss]);
        }
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        ma.RemoveAt(i);
        return i;
    }
    else if (isEqual(tres, p3))
    {
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int ss = 0; ss < ma[i].midPointNum; ss++)
        {
            pArray.Add(ma[i].midPoint[ss]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
```

```
                pArray.Add(ma[i].midPoint[ma[i].midPointNum - 1]);
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int ss = 0; ss < s + 1; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int ss = s; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
        }
        else
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int ss = 0; ss < s + 1; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].endPoint);
                for (int ss = s + 1; ss < ma[j].midPointNum; ss++)
                {
                    pArray.Add(ma[j].midPoint[ss]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                return j - 1;
```

```
                }
                else if (isEqual(tres, p3))
                {
                    pArray.Clear();
                    pArray.Add(ma[j].startPoint);
                    for (int ss = 0; ss < s + 1; ss++)
                    {
                        pArray.Add(ma[j].midPoint[ss]);
                    }
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    for (int ss = s; ss < ma[j].midPointNum; ss++)
                    {
                        pArray.Add(ma[j].midPoint[ss]);
                    }
                    pArray.Add(ma[j].endPoint);
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(j);
                    return j - 1;
                }
            }
        }
    }

    //还未检查
    //中间
    for (int ss = 0; ss < ma[i].midPointNum-1;ss++ )
    {
        p1 = mp[ma[i].midPoint[ss]];
        p2 = mp[ma[i].midPoint[ss+1]];
        p3 = mp[ma[j].startPoint];
        p4 = mp[ma[j].midPoint[0]];
        tres = CalIntersect(p1, p2, p3, p4);
        if (tres != null)//中间和开头
        {
            if (!isEqual(tres, p1) && !isEqual(tres, p2))
            {
                if (!isEqual(tres, p3) && !isEqual(tres, p4))
                {
                    int indexMP = addOnePointToMP(tres);
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    for (int s = 0; s < ss+1; s++)
                    {
```

```
                pArray.Add(ma[i].midPoint[s]);
            }
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            for (int s = ss + 1; s < ma[i].midPointNum; s++)
            {
                pArray.Add(ma[i].midPoint[s]);
            }
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            for (int s = 0; s < ma[j].midPointNum; s++)
            {
                pArray.Add(ma[j].midPoint[s]);
            }
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            ma.RemoveAt(i);
            return i;
        }
        else if(isEqual(tres,p3))
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            for (int s = 0; s < ss + 1; s++)
            {
                pArray.Add(ma[i].midPoint[s]);
            }
            pArray.Add(ma[j].startPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int s = ss + 1; s < ma[i].midPointNum; s++)
            {
                pArray.Add(ma[i].midPoint[s]);
            }
```

```
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                return i;
            }
        }
        else if(isEqual(tres,p1))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int s = 0; s < ss+1; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int s = ss + 1; s < ma[i].midPointNum; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                pArray.Add(ma[i].midPoint[ss]);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[i].midPoint[ss]);
                for (int s = 0; s < ma[j].midPointNum; s++)
                {
                    pArray.Add(ma[j].midPoint[s]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else if(isEqual(tres,p3))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
```

```
                    for (int s = 0; s < ss + 1; s++)
                    {
                        pArray.Add(ma[i].midPoint[s]);
                    }
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    for (int s = ss + 1; s < ma[i].midPointNum; s++)
                    {
                        pArray.Add(ma[i].midPoint[s]);
                    }
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(i);
                    return i;
                }
            }
        }
        p3 = mp[ma[j].midPoint[ma[j].midPointNum - 1]];
        p4 = mp[ma[j].endPoint];
        tres = CalIntersect(p1, p2, p3, p4);
        if (tres != null)//中间和结尾
        {
            if (!isEqual(tres, p1) && !isEqual(tres, p2))
            {
                if (!isEqual(tres, p3) && !isEqual(tres, p4))
                {
                    int indexMP = addOnePointToMP(tres);
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    for (int s = 0; s < ss + 1; s++)
                    {
                        pArray.Add(ma[i].midPoint[s]);
                    }
                    pArray.Add(indexMP);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    pArray.Add(indexMP);
                    for (int s = ss + 1; s < ma[i].midPointNum; s++)
                    {
                        pArray.Add(ma[i].midPoint[s]);
                    }
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
```

```
        pArray.Add(ma[j].startPoint);
        for (int s = 0; s < ma[j].midPointNum; s++)
        {
            pArray.Add(ma[j].midPoint[s]);
        }
        pArray.Add(indexMP);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(indexMP);
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        ma.RemoveAt(i);
        return i;
    }
    else if (isEqual(tres, p3))
    {
        int indexMP = addOnePointToMP(tres);
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int s = 0; s < ss + 1; s++)
        {
            pArray.Add(ma[i].midPoint[s]);
        }
        pArray.Add(ma[j].midPoint[ma[j].midPointNum-1]);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
        for (int s = ss + 1; s < ma[i].midPointNum; s++)
        {
            pArray.Add(ma[i].midPoint[s]);
        }
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int s = 0; s < ma[j].midPointNum; s++)
        {
            pArray.Add(ma[j].midPoint[s]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].midPoint[ma[j].midPointNum - 1]);
        pArray.Add(ma[j].endPoint);
```

```
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
            else
            {
                int indexMP = addOnePointToMP(tres);
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int s = 0; s < ss + 1; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].endPoint);
                for (int s = ss + 1; s < ma[i].midPointNum; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(i);
                return i;
            }
        }
        else if (isEqual(tres, p1))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int s = 0; s < ss + 1; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int s = ss + 1; s < ma[i].midPointNum; s++)
                {
                    pArray.Add(ma[i].midPoint[s]);
                }
```

```
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int s = 0; s < ma[j].midPointNum; s++)
            {
                pArray.Add(ma[j].midPoint[s]);
            }
            pArray.Add(ma[i].midPoint[ss]);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[i].midPoint[ss]);
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            ma.RemoveAt(i);
            return i;
        }
        else if (isEqual(tres, p3))
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            for (int s = 0; s < ss + 1; s++)
            {
                pArray.Add(ma[i].midPoint[s]);
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            for (int s = ss + 1; s < ma[i].midPointNum; s++)
            {
                pArray.Add(ma[i].midPoint[s]);
            }
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int s = 0; s < ma[j].midPointNum; s++)
            {
                pArray.Add(ma[j].midPoint[s]);
            }
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[i].midPoint[ma[i].midPointNum-1]);
            pArray.Add(ma[j].endPoint);
```

```
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(j);
                    ma.RemoveAt(i);
                    return i;
                }
                else
                {
                    pArray.Clear();
                    pArray.Add(ma[i].startPoint);
                    for (int s = 0; s < ss + 1; s++)
                    {
                        pArray.Add(ma[i].midPoint[s]);
                    }
                    ma.Add(new MyArc(pArray));
                    pArray.Clear();
                    for (int s = ss + 1; s < ma[i].midPointNum; s++)
                    {
                        pArray.Add(ma[i].midPoint[s]);
                    }
                    pArray.Add(ma[i].endPoint);
                    ma.Add(new MyArc(pArray));
                    ma.RemoveAt(i);
                    return i;
                }
            }
        }
        for (int s = 0; s < ma[j].midPointNum - 1; s++)
        {
            p3 = mp[ma[j].midPoint[s]];
            p4 = mp[ma[j].midPoint[s + 1]];
            tres = CalIntersect(p1, p2, p3, p4);
            if (tres != null)//中间对中间
            {
                if (!isEqual(tres, p1) && !isEqual(tres, p2))
                {
                    if (!isEqual(tres, p3) && !isEqual(tres, p4))
                    {
                        int indexMP = addOnePointToMP(tres);
                        pArray.Clear();
                        pArray.Add(ma[i].startPoint);
                        for (int sk = 0; sk < ss + 1; sk++)
                        {
                            pArray.Add(ma[i].midPoint[sk]);
                        }
```

```
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            for (int sk = ss + 1; sk < ma[i].midPointNum; sk++)
            {
                pArray.Add(ma[i].midPoint[sk]);
            }
            pArray.Add(ma[i].endPoint);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].startPoint);
            for (int sk = 0; sk < s+1; s++)
            {
                pArray.Add(ma[j].midPoint[sk]);
            }
            pArray.Add(indexMP);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(indexMP);
            for (int sk = s+1; sk < ma[j].midPointNum; s++)
            {
                pArray.Add(ma[j].midPoint[sk]);
            }
            pArray.Add(ma[j].endPoint);
            ma.Add(new MyArc(pArray));
            ma.RemoveAt(j);
            ma.RemoveAt(i);
            return i;
        }
        else if (isEqual(tres, p3))
        {
            pArray.Clear();
            pArray.Add(ma[i].startPoint);
            for (int sk = 0; sk < ss + 1; sk++)
            {
                pArray.Add(ma[i].midPoint[sk]);
            }
            pArray.Add(ma[j].midPoint[s]);
            ma.Add(new MyArc(pArray));
            pArray.Clear();
            pArray.Add(ma[j].midPoint[s]);
            for (int sk = ss + 1; sk < ma[i].midPointNum; sk++)
            {
```

```
                    pArray.Add(ma[i].midPoint[sk]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int sk = 0; sk < s + 1; s++)
                {
                    pArray.Add(ma[j].midPoint[sk]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int sk = s; sk < ma[j].midPointNum; s++)
                {
                    pArray.Add(ma[j].midPoint[sk]);
                }
                pArray.Add(ma[j].endPoint);
                ma.Add(new MyArc(pArray));
                ma.RemoveAt(j);
                ma.RemoveAt(i);
                return i;
            }
        }
        else if (isEqual(tres, p1))
        {
            if (!isEqual(tres, p3) && !isEqual(tres, p4))
            {
                pArray.Clear();
                pArray.Add(ma[i].startPoint);
                for (int sk = 0; sk < ss + 1; sk++)
                {
                    pArray.Add(ma[i].midPoint[sk]);
                }
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                for (int sk = ss; sk < ma[i].midPointNum; sk++)
                {
                    pArray.Add(ma[i].midPoint[sk]);
                }
                pArray.Add(ma[i].endPoint);
                ma.Add(new MyArc(pArray));
                pArray.Clear();
                pArray.Add(ma[j].startPoint);
                for (int sk = 0; sk < s + 1; s++)
```

```
        {
            pArray.Add(ma[j].midPoint[sk]);
        }
        pArray.Add(ma[i].midPoint[ss]);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[i].midPoint[ss]);
        for (int sk = s+1; sk < ma[j].midPointNum; s++)
        {
            pArray.Add(ma[j].midPoint[sk]);
        }
        pArray.Add(ma[j].endPoint);
        ma.Add(new MyArc(pArray));
        ma.RemoveAt(j);
        ma.RemoveAt(i);
        return i;
    }
    else if (isEqual(tres, p3))
    {
        pArray.Clear();
        pArray.Add(ma[i].startPoint);
        for (int sk = 0; sk < ss + 1; sk++)
        {
            pArray.Add(ma[i].midPoint[sk]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        for (int sk = ss; sk < ma[i].midPointNum; sk++)
        {
            pArray.Add(ma[i].midPoint[sk]);
        }
        pArray.Add(ma[i].endPoint);
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        pArray.Add(ma[j].startPoint);
        for (int sk = 0; sk < s + 1; s++)
        {
            pArray.Add(ma[j].midPoint[sk]);
        }
        ma.Add(new MyArc(pArray));
        pArray.Clear();
        for (int sk = s; sk < ma[j].midPointNum; s++)
        {
            pArray.Add(ma[j].midPoint[sk]);
```

```
                                }
                                pArray.Add(ma[j].endPoint);
                                ma.Add(new MyArc(pArray));
                                ma.RemoveAt(j);
                                ma.RemoveAt(i);
                                return i;
                            }
                        }
                    }
                }
            }
            return j;
        }

        /// <summary>
        ///  生成多边形
        /// </summary>
        private void trackPolygon()
        {
            double EnvMaxx = double.MinValue, EnvMinx = double.MaxValue, EnvMaxy =
        double.MinValue, EnvMiny = double.MaxValue;
            for (int i = 0; i < data.Count; i++)
            {
                if (EnvMaxx < data[i].getX())
                    EnvMaxx = data[i].getX();
                if (EnvMinx > data[i].getX())
                    EnvMinx = data[i].getX();
                if (EnvMaxy < data[i].getY())
                    EnvMaxy = data[i].getY();
                if (EnvMiny > data[i].getY())
                    EnvMiny = data[i].getY();
            }

            int[] trackTimes = new int[ma.Count];//记录某弧段被用了几次，是顺时针还
        是逆时针
            for (int i = 0; i < ma.Count; i++)
                trackTimes[i] = 0;

            for (int i = 0; i < mp.Count; i++)
            {
                if (mp[i].lineNum >
        1&&isInEnv(mp[i],EnvMaxx,EnvMinx,EnvMaxy,EnvMiny))//是内部结点
                {
                    //将结点拓扑关联的线段按照角度从小到大排列
```

```
                for (int j = 0; j < mp[i].lineNum - 1; j++)
                {
                    for (int k = j + 1; k < mp[i].lineNum; k++)
                    {
                        if (calAngle(i,j) > calAngle(i,k))
                        {
                            int tt = mp[i].relLine[j];
                            mp[i].relLine[j] = mp[i].relLine[k];
                            mp[i].relLine[k] = tt;
                        }
                    }
                }
                for (int j = 0; j < mp[i].lineNum; j++)
                {
                    if (Math.Abs(trackTimes[convert(mp[i].relLine[j])]) != 2 &&
Math.Abs(trackTimes[convert(mp[i].relLine[(j + 1) % mp[i].lineNum])]) != 2)
                    {
                        List<int> alist = new List<int>();
                        int tempArc = mp[i].relLine[(j + 1) % mp[i].lineNum];
                        while ((tempArc >= 0 && trackTimes[convert(tempArc)] <=
0 && trackTimes[convert(tempArc)] > -2) || (tempArc < 0 &&
trackTimes[convert(tempArc)] >= 0 && trackTimes[convert(tempArc)]<2))
                        {
                            alist.Add(tempArc);
                            if (trackTimes[convert(tempArc)] > 0)
                                trackTimes[convert(tempArc)]++;
                            else if (trackTimes[convert(tempArc)] < 0)
                                trackTimes[convert(tempArc)]--;
                            else
                                trackTimes[convert(tempArc)] = tempArc >= 0 ?
1 : -1;

                            int nextP;
                            if (tempArc >= 0)//找末结点
                            {
                                nextP = ma[tempArc].endPoint;
                                ma[tempArc].rightPoly = mpol.Count;
                            }
                            else//找首节点
                            {
                                nextP = ma[convert(tempArc)].startPoint;
                                ma[convert(tempArc)].leftPoly = mpol.Count;
                            }
                            for (int l = 0; l < mp[nextP].lineNum - 1; l++)
```

```
                                {
                                    for (int k = l + 1; k < mp[nextP].lineNum; k++)
                                    {
                                        if (calAngle(nextP,l) > calAngle(nextP,k))
                                        {
                                            int tt = mp[nextP].relLine[l];
                                            mp[nextP].relLine[l] =
mp[nextP].relLine[k];
                                            mp[nextP].relLine[k] = tt;
                                        }
                                    }
                                }
                                for(int k=0;k<mp[nextP].lineNum;k++)
                                {

if(Math.Abs(convert(tempArc))==Math.Abs(convert(mp[nextP].relLine[k])))
                                    {
                                        tempArc = mp[nextP].relLine[(k + 1) %
mp[nextP].lineNum];
                                        break;
                                    }
                                }
                            }
                            if (alist.Count != 0)
                                mpol.Add(new MyPolygon(alist));
                        }
                    }
                }
            }
            //生成多边形的拓扑关系
            for(int i=0;i<mpol.Count;i++)
            {
                for(int j=0;j<mpol[i].arcList.Count;j++)
                {

if(ma[convert(mpol[i].arcList[j])].leftPoly==i&&ma[convert(mpol[i].arcList[j])].right
Poly!=-1)
                    {
                        mpol[i].adjPoly.Add(ma[convert(mpol[i].arcList[j])].rightPoly);
                        mpol[i].adjPolyNum++;
                    }
                    if (ma[convert(mpol[i].arcList[j])].rightPoly == i &&
ma[convert(mpol[i].arcList[j])].leftPoly != -1)
                    {
```

```
                        mpol[i].adjPoly.Add(ma[convert(mpol[i].arcList[j])].leftPoly);
                        mpol[i].adjPolyNum++;
                    }
                }
            }
        }

/// <summary>
///  绘制拓扑数据
/// </summary>
private void showTopo()
{
        pictureBox1.Refresh();
        Graphics g = pictureBox1.CreateGraphics();
        SolidBrush myBrush = new SolidBrush(Color.Red);
        // Pen myPen = new Pen(Color.Red);
        for (int i = 0; i < mpol.Count; i++)
        {
            myBrush.Color =
Color.FromArgb(125,(i*35)%256,(i*76)%256,(i*90)%256);
            int pointNumPoly = 0;
            for (int j = 0; j < mpol[i].arcList.Count; j++)
            {
                pointNumPoly += ma[convert(mpol[i].arcList[j])].midPointNum + 1;
            }
            Point[] tmp = new Point[pointNumPoly];
            pointNumPoly = 0;
            for (int j = 0; j < mpol[i].arcList.Count; j++)
            {
                if (mpol[i].arcList[j] >= 0)
                {
                    tmp[pointNumPoly] = new
Point((int)((mp[ma[convert(mpol[i].arcList[j])].startPoint].x - minx) / scale + margin),
(int)(pictureBox1.Height - (mp[ma[convert(mpol[i].arcList[j])].startPoint].y - miny) /
scale - margin));
                    pointNumPoly++;
                    for (int k = 0; k < ma[convert(mpol[i].arcList[j])].midPointNum;
k++)
                    {
                        tmp[pointNumPoly] = new
Point((int)((mp[ma[convert(mpol[i].arcList[j])].midPoint[k]].x - minx) / scale +
margin), (int)(pictureBox1.Height -
(mp[ma[convert(mpol[i].arcList[j])].midPoint[k]].y - miny) / scale - margin));
                        pointNumPoly++;
```

```
                    }
                }
                else
                {
                    tmp[pointNumPoly] = new
Point((int)((mp[ma[convert(mpol[i].arcList[j])].endPoint].x - minx) / scale + margin),
(int)(pictureBox1.Height - (mp[ma[convert(mpol[i].arcList[j])].endPoint].y - miny) /
scale - margin));
                    pointNumPoly++;
                    for (int k = ma[convert(mpol[i].arcList[j])].midPointNum-1;
k >=0; k--)
                    {
                        tmp[pointNumPoly] = new
Point((int)((mp[ma[convert(mpol[i].arcList[j])].midPoint[k]].x - minx) / scale +
margin), (int)(pictureBox1.Height -
(mp[ma[convert(mpol[i].arcList[j])].midPoint[k]].y - miny) / scale - margin));
                        pointNumPoly++;
                    }
                }

            }
            g.FillPolygon(myBrush, tmp);
        }
        // myPen.Dispose();
        myBrush.Dispose();
        g.Dispose();
}
```

3.8 计算多边形周长和面积

计算多边形周长和面积的代码如下。

```
//计算多边形周长
public double GetPerimeter(List<MyPoint> mp,List<MyArc> ma)
{
    double res = 0;
    //假设点线面都按照 ID 升序排列
    for(int i=0;i<arcNum;i++)
    {
        res += ma[convert(arcList[i])].GetLength(mp);
    }
    return res;
}
//计算多边形的面积
```

```
public double GetArea(List<MyPoint> mp, List<MyArc> ma)
{
    double res=0;
    MyPoint tmp = mp[ma[convert(arcList[arcList.Count - 1])].startPoint];
    foreach(int i in arcList)
    {
        res += TriArea(tmp, mp[ma[convert(i)].startPoint], mp[ma[convert(i)].endPoint]);
    }
    return res;
}
//计算三角形面积
public double TriArea(MyPoint p1,MyPoint p2,MyPoint p3)
{
    return 0.5*Math.Abs((p2.x-p1.x)*(p3.y-p1.y)-(p2.y-p1.y)*(p3.x-p1.x));
}
```