熱區分析

空間分析 2020.06.01

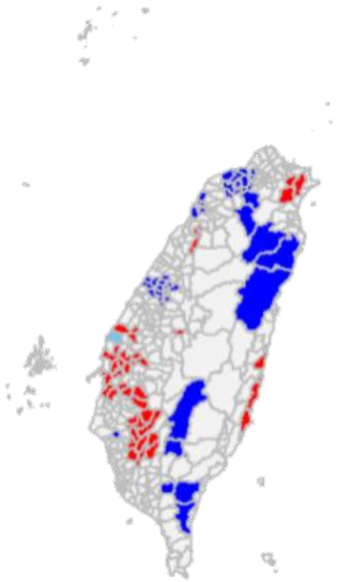
TA 杜承軒

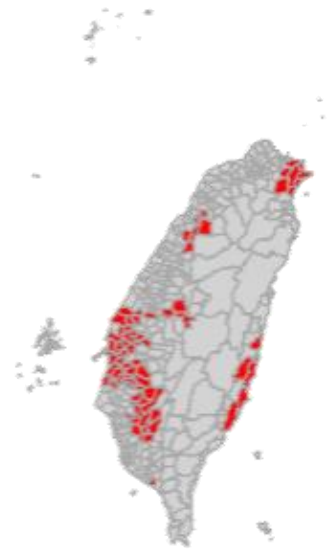
Lab 10

- 資料：Popn_TWN2.shp

繪製台灣鄉鎮高齡人口比例的主題地圖：
（定義：老年人口／全部人口）

【鄰近定義：Contiguity (Queen)】
1. 原始數值
2. LISA map (p-value < 0.05, 區分 HH, HL, LH, LL)
3. Standardized Gi * values
   (p-value < 0.05, 區分 cluster, non-cluster)





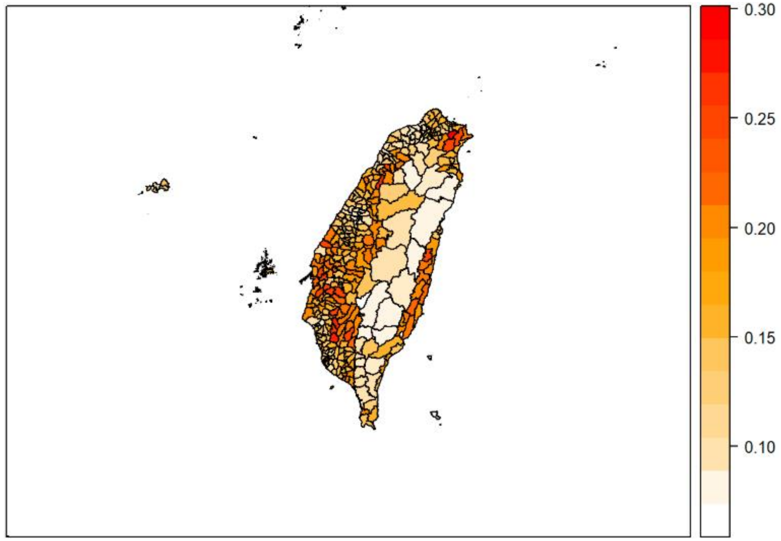
透過spplot繪製面量圖

※選顏色：「白→橘→紅」的漸層色

```
lm.palette=colorRampPalette(c( "white","orange","red"), space = "rgb")

spplot(TW, zcol="old", col.regions=lm.palette(20), main="標題")
```

圖層　畫圖數值　※分20格漸層色



實作

LISA

Gi*

包含自己的
鄰近定義

定義「鄰近」

```
TW.nb = poly2nb(TW)
```

```
TW.nb = poly2nb(TW)
TW.nb.in = include.self(TW.nb)
```

建立鄰近表

```
TW.nb.w = nb2listw(TW.nb,
                  zero.policy=T)
```

```
TW.nb.w.in = nb2listw(TW.nb.in)
```

區域空間
自相關運算

```
LISA = localmoran(old, TW.nb.w,
       zero.policy = T,
       alternative = "two.sided")
```

```
Gi = localG(old,TW.nb.w.in)
```

```
> LISA
              Ii   E.Ii    Var.Ii         Z.Ii    Pr(z != 0)
220  0.8094220277 -0.025 0.17429168  1.998699187 4.564091e-02
221  0.6620073103 -0.025 0.22386090  1.452018784 1.464964e-01
222  1.3953564727 -0.025 0.17429168  3.402193655 6.684725e-04
223  0.5999538193 -0.025 0.14124553  1.662878712 9.633672e-02
224  1.5232521605 -0.025 0.14124553  4.119593286 3.795417e-05
225  1.3501517812 -0.025 0.17429168  3.293914418 9.880258e-04
226  2.3360250470 -0.025 0.14124553  6.282221450 3.337689e-10
227 -0.0299052525 -0.025 0.08616861 -0.016710399 9.866677e-01
228  0.0003684787 -0.025 0.11764114  0.073963051 9.410398e-01
229 -0.0043165576 -0.025 0.17429168  0.049543250 9.604864e-01
230 -0.0327045528 -0.025 0.06614064 -0.029958028 9.761005e-01
```

Local Moran's I
LISA[,1]

Z score
LISA[,4]

P value
LISA[,5]

```
> Gi
 [1]  1.8911025  1.7181396  2.5357910  2.4823288
 [5]  3.7590712  2.4905072  4.3849408  1.7080833
 [9] -0.1426438  0.2470504  0.1209070 -1.7733190
[13]  2.4211648  2.8866465  2.4180649  2.9475747
[17]  0.9903472 -0.9465509  0.3367046 -0.9960144
[21] -1.4617826 -1.4423588 -1.6701713 -1.7999710
```

Z score of Gi*

LISA與繪圖

```
LISA = localmoran(old, TW.nb.w,zero.policy = T, alternative = "two.sided" )
```

※ 可以透過data.frame(LISA)來轉成表格格式

```
> LISA
             Ii    E.Ii     Var.Ii        Z.Ii  Pr(z > 0)
220 0.8094220277 -0.025 0.17429168 1.998699187 2.282046e-02
221 0.6620073103 -0.025 0.22386090 1.452018784 7.324819e-02
222 1.3953564727 -0.025 0.17429168 3.402193655 3.342363e-04
223 0.5999538193 -0.025 0.14124553 1.662878712 4.816836e-02
224 1.5232521605 -0.025 0.14124553 4.119593286 1.897709e-05
```

alternative = "greater"
預設：是否和鄰居相似(正相關)

HH
LL
Not-Sig.

alternative = "two.sided"
我們要的：是否和鄰居有相關

```
  Pr(z != 0)
4.564091e-02
1.464964e-01
6.684725e-04
9.633672e-02
3.795417e-05
```

HH
HL
LL
LH
Not-Sig.

區分顏色

```
LISA = localmoran(old, TW.nb.w, zero.policy=T, alternative ="two.sided")
diff = old - mean(old) # diff看自己和平均比起來算是H還是L
z = LISA[,4]
quad = c() #不要用vector()
quad[diff>0 & z>0] = 1 # H-H
quad[diff<0 & z>0] = 2 # L-L
quad[diff>0 & z<0] = 3 # H-L
quad[diff<0 & z<0] = 4 # L-H
quad[LISA[, 5]>0.05]=5 # 不顯著，設定雙尾所以用0.05比較就可以
```

著色

繪圖

```
colors=c("red", "blue", "lightpink", "skyblue2", rgb(.95, .95, .95))
plot(TW, border="grey", col=colors[quad], main = "LISA Map")
legend("bottomright",legend=c("HH","LL","HL","LH","NS"),fill=colors,bty="n",cex=0.7,y.intersp=1,x.intersp=1)
```

Gi*與繪圖

```
Gi = localG(old,TW.nb.w.in)
```

※ 會列出Gi*的Z分數

※ 可以透過as.vector(Gi)來轉成向量格式

```
> Gi
 [1]  1.8911025  1.7181396  2.5357910  2.4823288
 [5]  3.7590712  2.4905072  4.3849408  1.7080833
 [9] -0.1426438  0.2470504  0.1209070 -1.7733190
[13]  2.4211648  2.8866465  2.4180649  2.9475747
```

cluster

1.645

non-cluster

```
Gi = localG(old,TW.nb.w.in)
LG = as.vector(Gi)
```

區分顏色

```
quad = c() #不要用vector()
quad[LG>=1.645] = 1 # cluster
quad[LG <1.645] = 2 # non-cluster
```

繪圖

```
colors=c("red", "lightgray")
plot(TW, border="grey", col=colors[quad], main = "Cluster Map")
legend("bottomright", c("Cluster","Non-cluster"), fill=colors,bty="n",cex=0.7,y.intersp=1,x.intersp=1)
```

補充

```
Gi = localG(old, TW.nb.w.in, return_internals =T)
```

※ 可以列出每個格子的Gi*，以及期望值、變異數

```
> attr(Gi,"internals")
```

	G	EG	VG
1	0.0443024793	0.02439024	1.108689e-04
2	0.0444890960	0.02439024	1.368440e-04
3	0.0510906836	0.02439024	1.108689e-04
4	0.0482406792	0.02439024	9.231537e-05
5	0.0605077328	0.02439024	9.231537e-05
6	0.0506138713	0.02439024	1.108689e-04

計算

Moran's I

$$I = \frac{n}{W}\frac{\sum_i \sum_j w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_i (x_i-\bar{x})^2}$$

$$\xrightarrow[]{\tilde{x}_i = x_i - \bar{x}} \frac{n}{W}\frac{\sum_i \sum_j w_{ij}\,\tilde{x}_i\,\tilde{x}_j}{\sum_i \tilde{x}_i^{\,2}}$$

R package – spdep

$$I = \frac{n}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^n (x_i-\bar{x})^2}$$

- $W = \sum_i \sum_j w_{ij}$ P.S. 列標準化時，$W = n$
- $\sum_i (x_i-\bar{x})^2 = n\,\sigma_x^2 = (n-1)\,s_x^2 = (n-1)\,s_{\tilde{x}}^2$

```
> TP.nb=poly2nb(TP)
> TP.nb.w=nb2listw(TP.nb)
> M=moran.test(x,TP.nb.w)
> M$estimate[1]
Moran I statistic
      -0.01261841
```

```
> TP.nb.M=nb2mat(TP.nb)
> xx=x-mean(x)
> sum(TP.nb.M*(xx%*%t(xx)))/sum(xx^2)
[1] -0.01261841
> sum(TP.nb.M*(xx%*%t(xx)))/(var(xx)*11)
[1] -0.01261841
```

計算

Local Moran's I

$$I_i = \frac{x_i - \bar{x}}{s^2}\sum_{j\neq i} w_{ij}(x_j - \bar{x}) = \mathbb{x}_i \sum_j w_{ij}\mathbb{x}_j$$

$$I_i = z_i \sum_j w_{ij} z_j \quad ★ 預設$$

- $\mathbb{x} = \frac{x_i - \bar{x}}{s}$
- $z_i = \frac{x_i - \bar{x}}{\sigma}$

z_i

```
> LISA=localmoran(x,TP.nb.w)
> LISA[1]
[1] 0.005094452
> z=(x-mean(x))/(sd(x)*sqrt(11/12))
> z[1]*sum(TP.nb.M[1,]*z)
[1] 0.005094452
```

$\mathbb{x}_i$

```
> LISA=localmoran(x,TP.nb.w,mlvar=F)
> LISA[1]
[1] 0.004669914
> z=(x-mean(x))/sd(x)
> z[1]*sum(TP.nb.M[1,]*z)
[1] 0.004669914
```

R package – spdep

$$I_i = \frac{(x_i - \bar{x})}{\sum_{k=1}^{n}(x_k - \bar{x})^2/(n-1)}\sum_{j=1}^{n} w_{ij}(x_j - \bar{x})$$

`localmoran(mlvar=TRUE)`

mlvar: values of local Moran's I are reported using the variance of the variable of interest (sum of squared deviances over n), but can be reported as the sample variance, dividing by (n-1) instead

P.S.

$$I_i = \frac{x_i - \bar{x}}{s_i^2}\sum_{j\neq i} w_{ij}(x_j - \bar{x})\,;\; s_i^2 = \frac{\sum_{j\neq i} w_{ij}(x_j - \bar{x})^2}{n-1}$$

```
> lx=xx[1]*sum(TP.nb.M[1,]*xx)
> si2=var(x[-1])*10/11
> lx/si2
[1] 0.004670523
> xx*(TP.nb.M%*%xx)/
sapply(1:12,function(i) var(x[-i])*10/11)
```

補充：用矩陣方法一次求得所有I_i

```
> z*(TP.nb.M%*%z)
```

計算

Getis-Ord General G

$$G = \frac{\sum_i \sum_j w_{ij} x_i x_j}{\sum_i \sum_j x_i x_j}, j \neq i$$

$$\left(當 w_{ii} = 0 \xrightarrow{\text{ignore } j \neq i} G = \frac{\sum_i \sum_j w_{ij} x_i x_j}{\sum_i \sum_j x_i x_j - \sum_i x_i^2} \right)$$

```
> G=globalG.test(x,TP.nb.w)
> G$estimate[1]
Global G statistic
        0.09243927
> G.num=sum(TP.nb.M*(x%*%t(x)))
> G.den=sum(x%*%t(x))-sum(diag(x%*%t(x)))
> G.num/G.den
[1] 0.09243927
```

---

*Getis-Ord Gi**

$$G_i^* = \frac{\sum_j w_{ij} x_j}{\sum_j x_j}$$

```
> Gi.=localG(x,TP.nb.w.in,return_internals=T)
> attr(Gi.,"internals")[,1]
0.0862 0.0885 0.0923 0.0868 0.0845 ……
> TP.nb.M.in%*%x/sum(x)
0.0862 0.0885 0.0923 0.0868 0.0845 ……
```

Getis-Ord Gi

$$G_i = \frac{\sum_j w_{ij} x_j}{\sum_j x_j}, j \neq i$$

```
> Gi=localG(x,TP.nb.w,return_internals=T)
> attr(Gi,"internals")[,1]
0.0946 0.0966 0.0969 0.0948 0.0948 ……
> TP.nb.M%*%x/(sum(x)-x)
0.0946 0.0966 0.0969 0.0948 0.0948 ……
```