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Apêndice A

Extensividade da Entropia

Considere a expressão para a entropia de informação de Shannon dada pela expressão (3.3). Para 2 sistemas A e B independentes, a entropia do sistema combinado é:

$$S(p_A * p_B) = -\sum_{j=1}^{m}\sum_{i=1}^{n} p_i p_j \ln(p_i p_j) \qquad \text{(A.1)}$$

$$S(p_A * p_B) = -\sum_{j=1}^{m}\sum_{i=1}^{n} p_i p_j \ln p_i - \sum_{j=1}^{m}\sum_{i=1}^{n} p_i p_j \ln p_j \qquad \text{(A.2)}$$

$$S(p_A * p_B) = \left(-\sum_{j=1}^{m} p_j\right)\left(\sum_{i=1}^{n} p_i \ln p_i\right) - \left(\sum_{i=1}^{n} p_i\right)\left(\sum_{j=1}^{m} p_j \ln p_j\right) \text{(A.3)}$$

$$S(p_A * p_B) = -\sum_{i=1}^{n} p_i \ln p_i - \sum_{j=1}^{m} p_i \ln p_i \qquad \text{(A.4)}$$

$$S(p_A * p_B) = S[p_A] + S[p_B] \qquad \text{(A.5)}$$

ou seja, a soma das entropias individuais, garantindo que ela é uma grandeza extensiva.

Para o caso da estatística generalizada, a entropia é dada pela equação (3.11):

$$S_q[p] = \frac{1 - \sum_{i=1}^{W} p_i^q}{q-1} \qquad \text{(A.6)}$$

Considerando o caso particular em que $p_i = W^{-1}$, com W o número total de estados (distribuição uniforme), temos que:

$$\sum_{i=1}^{W} p_i^q = \sum_{i=1}^{W} W^{-q} = W\ W^{-q} = W^{1-q} \qquad \text{(A.7)}$$

A entropia do sistema é dada então, por:

$$S_q[p] = \frac{1 - W^{(1-q)}}{q-1} \tag{A.8}$$

Dados dois sistemas independentes A e B, a entropia do sistema combinado é:

$$S_q[p_A * p_B] = \frac{1 - \sum_{i=1}^{W_A} \sum_{j=1}^{W_B} (p_i^q p_j^q)}{q-1} \tag{A.9}$$

Para o caso de distribuição uniforme, usando (A.7):

$$S_q[p_A * p_B] = \frac{1 - (W_A{}^{(1-q)})(W_B{}^{(1-q)})}{q-1} \tag{A.10}$$

Escrevendo a entropia total como a soma de entropias individuais mais outros termos, teremos:

$$S_q[p] = \left(\frac{1}{q-1}\right)\left[(1 - W_A^{(1-q)}) + (1 - W_B^{(1-q)}) + (-1 + W_A^{(1-q)} + W_B^{(1-q)} - W_A^{(1-q)} W_B^{(1-q)})\right] \tag{A.11}$$

$$S_q[p] = \left(\frac{1}{q-1}\right)\left[(1 - W_A^{(1-q)}) + (1 - W_B^{(1-q)}) - (1 - W_A^{(1-q)})(1 - W_B^{(1-q)})\right] \tag{A.12}$$

Usando (A.8):

$$S_q[p] = S_q[p_A] + S_q[p_B] - \left[\frac{1}{(q-1)}\right](1 - W_A^{(1-q)})(1 - W_B^{(1-q)}) \tag{A.13}$$

$$S_q[p] = S_q[p_A] + S_q[p_B] - (q-1) S_q[p_A] S_q[p_B] \tag{A.14}$$

Assim, a entropia generalizada é uma grandeza não-extensiva.

Apêndice B

Algoritmo para misturar dados em série.

```
    program Misturar

    implicit real(a-h,o-z)
    parameter n=10
    real XX(n)
  integer indx(n)

  open (unit=3,file='data1s.dat',status= 'unknown')
  open (unit=5,file='data1.dat',status= 'old')

    do 20 i=1,n
    read(5,*)x
    XX(i)=x
20        continue

    call indexx(n,XX,indx)

    do 30 i=1,n
    write(3,*)indx(i),XX(i)
    write(*,*)i,indx(i),XX(i)
30          continue

    stop
  end

    SUBROUTINE indexx(n,arr,indx)
    INTEGER n,indx(n),M,NSTACK
    REAL arr(n)
    PARAMETER (M=7,NSTACK=50)
    INTEGER i,indxt,ir,itemp,j,jstack,k,l,istack(NSTACK)
    REAL a
    do 11 j=1,n
```

```
        indx(j)=j
11      continue
      jstack=0
      l=1
      ir=n
1      if(ir-l.lt.M)then
        do 13 j=l+1,ir
          indxt=indx(j)
          a=arr(indxt)
          do 12 i=j-1,l,-1
            if(arr(indx(i)).le.a)goto 2
            indx(i+1)=indx(i)
12          continue
          i=l-1
2          indx(i+1)=indxt
13        continue
        if(jstack.eq.0)return
        ir=istack(jstack)
        l=istack(jstack-1)
        jstack=jstack-2
      else
        k=(l+ir)/2
        itemp=indx(k)
        indx(k)=indx(l+1)
        indx(l+1)=itemp
        if(arr(indx(l)).gt.arr(indx(ir)))then
          itemp=indx(l)
          indx(l)=indx(ir)
          indx(ir)=itemp
        endif
        if(arr(indx(l+1)).gt.arr(indx(ir)))then
          itemp=indx(l+1)
          indx(l+1)=indx(ir)
          indx(ir)=itemp
        endif
        if(arr(indx(l)).gt.arr(indx(l+1)))then
          itemp=indx(l)
```

```
      indx(l)=indx(l+1)
      indx(l+1)=itemp
    endif
    i=l+1
    j=ir
    indxt=indx(l+1)
    a=arr(indxt)
3     continue
      i=i+1
    if(arr(indx(i)).lt.a)goto 3
4     continue
      j=j-1
    if(arr(indx(j)).gt.a)goto 4
    if(j.lt.i)goto 5
    itemp=indx(i)
    indx(i)=indx(j)
    indx(j)=itemp
    goto 3
5     indx(l+1)=indx(j)
    indx(j)=indxt
    jstack=jstack+2
    if(jstack.gt.NSTACK)pause 'NSTACK too small in indexx'
    if(ir-i+1.ge.j-l)then
      istack(jstack)=ir
      istack(jstack-1)=i
      ir=j-1
    else
      istack(jstack)=j-1
      istack(jstack-1)=l
      l=i
    endif
  endif
  goto 1
  END
```