Package 'SII'

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Type Package

Title Calculate ANSI S3.5-1997 Speech Intelligibility Index

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Description This package calculates ANSI S3.5-1997 Speech Intelligibility Index (SII), a standard method for computing the intelligibility of speech from acoustical measurements of speech, noise, and hearing thresholds. This package includes data frames corresponding to Tables 1 - 4 in the ANSI standard as well as a function utilizing these tables and user-provided hearing threshold and noise level measurements to compute the SII score. The methods implemented here extend the standard computations to allow calculation of SII when the measured frequencies do not match those required by the standard by applying interpolation to obtain values for the required frequencies
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SII-package *Calculate ANSI S3.5-1997 Speech Intelligibility Index*

Description

This package calculates ANSI S3.5-1997 Speech Intelligibility Index (SII), a standard method for computing the intelligibility of speech from acoustical measurements of speech, noise, and hearing thresholds. This package includes data frames corresponding to Tables 1 - 4 in the ANSI standard as well as a function utilizing these tables and user-provided hearing threshold and noise level measurements to compute the SII score. The methods implemented here extend the standard computations to allow calculation of SII when the measured frequencies do not match those required by the standard by applying interpolation to obtain values for the required frequencies.

Author(s)

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References

ANSI S3.5-1997, "American National Standard Methods for Calculation of the Speech Intelligibility Index" American National Stan- dards Institute, New York.

Other software programs for calculating SII are available from http://www.sii.to/html/programs.html.

Examples

```
## Example C.1 from ANSI S3.5-1997 Annex C
sii.C1 <- sii(
              speech   = c(50.0, 40.0, 40.0, 30.0, 20.0,  0.0),
              noise    = c(70.0, 65.0, 45.0, 25.0,  1.0,-15.0),
              threshold= c( 0.0,  0.0,  0.0,  0.0,  0.0,  0.0),
              method="octave"
      )
sii.C1                        # rounded to 2 digits by default
print(sii.C1$sii, digits=20)  # full precision
summary(sii.C1)               # full details
plot(sii.C1)                  # plot
## The value given in the Standard is $0.504$.
```

critical *Constants Tables for ANSI S3.5-1997 Speech Intelligibility Index (SII)*

Description

Tables of constants for ANSI S3.5-1997 Speech Intelligibility Index (SII)

Usage

```
data(critical)
data(equal)
data(onethird)
data(octave)
data(overall.spl)
```

Format

Each data frames has 6-21 observations and a subset of the following variables:

`fi` Center frequency of SII band, Hz

`li` Lower limit of frequency band, Hz

`hi` Upper limit of frequency band, Hz

`Deltai` Band width adjustment, dB

`Ii` Band importance function

`normal`, `raised`, `loud` **and** `shout` Standard spectrum levels for vocal effort levels "normal", "raised", "loud", and "shout", respectively, dB

`Xi` Spectrum level of internal noise, dB

`Fi` Band importance function (weight)

Details

These data objects provide constant tables 1 – 4 from the ANSI S3.5-1997.

`critical` Table 1: Critical band SII procedure constants

`equal` Table 2:Equally contributing (17 band) critical band SII

`onethird` Table 3: One-third octave band SII procedure constants

`octave` Table 4: Octave band SII procedure constants

`overall.spl` Overall sound pressure level (SPL) for the for vocal effort levels "normal", "raised", "loud", and "shout", in dB

Source

ANSI S3.5-1997, "American National Standard Methods for Calculation of the Speech Intelligibility Index" American National Standards Institute, New York.

References

ANSI S3.5-1997, "American National Standard Methods for Calculation of the Speech Intelligibility Index" American National Standards Institute, New York.

Examples

```
data(critical)
critical # show entire table

data(equal)
names(equal)
equal$fi # extract just the frequency band centers

data(onethird)
barplot(onethird$Ii) # plot band importance function (weights)

data(octave)
round(octave, digits=2) # just 2 digits

data(overall.spl)
overall.spl
```

---

sic.critical *Alternative ANSI S3.5-1997 SII Transfer Function Weights*

Description

Alternative ANSI S3.5-1997 Speech Intelligibility Index (SII) transfer function weights for for various types of speech material.

Usage

```
data(sic.critical)
data(sic.onethird)
data(sic.octave)
```

Format

Each data frame contains the following 8 variables, each corresponding the the transfer function weights for a specific type of speech material:

`fi` Center frequency, Hz

`SII` Standard SII transfer function (weights)

`NNS` NNS (various nonsense syllable tests where most of the English phonems occur equally often)

`CID22` CID-W22 (PB-words)

`NU6` NU6 monosyllables

`DRT` DRT (Diagnostic Rhyme Test)

`ShortPassage` short passages of easy reading material

`SPIN` SPIN monosyllables

`CST` Connected Speech Test

Details

`sic.critical` provides alternative weights for the critical band SII procedure.

`sic.threeoctave` provides alternative weights for the one-third octave frequency band SII procedure.

`octave` provides alternative weights for the octave frequency band SII procedure.

note

There is no table of alternative weights for the equally-weighted SII band procedure as the weights for this method are (by definition) constant across all bands.

Source

All values except the `CST` columns are from:

ANSI S3.5-1997, "American National Standard Methods for Calculation of the Speech Intelligibility Index" American National Standards Institute, New York.

Values in the `CST` columns are from: http://www.sii.to/CSTdata.txt

References

ANSI S3.5-1997, "American National Standard Methods for Calculation of the Speech Intelligibility Index" American National Standards Institute, New York.

Examples

```
## Load the alternative weights for the critical band method
data(sic.critical)

## display the weights
round(sic.critical,3)

## draw a comparison plot
ngroup <- ncol(sic.critical)
matplot(x=sic.critical[,1], y=sic.critical[,-1],
        type="o",
        xlab="Frequency, Hz",
        ylab="Weight",
        log="x",
        lty=1:ngroup,
        col=rainbow(ngroup)
)
legend(
       "topright",
       legend=names(sic.critical)[-1],
```

```
        pch=as.character(1:ngroup),
        lty=1:ngroup,
        col=rainbow(ngroup)
        )

data(threeoctave)
data(octave)
```

---

sii *Compute ANSI S3.5-1997 Speech Intelligibility Index (SII)*

Description

Compute the Speech Intelligibility Index (SII) described by ANSI specification S3.5-1997, including extensions for conductive hearing loss. Optionally apply interpolation obtain values for the required frequencies.

Usage

```
sii(speech = c("normal", "raised", "loud", "shout"),
    noise, threshold, loss, freq,
    method = c("critical", "equal-contributing",
               "one-third octave", "octave"),
    importance = c("SII", "NNS", "CID22", "NU6", "DRT",
                   "ShortPassage", "SPIN", "CST"),
    interpolate=FALSE)
## S3 method for class 'SII'
print(x, digits=3, ...)
## S3 method for class 'SII'
plot(x, ...)
## S3 method for class 'SII'
summary(object, digits=2, ...)
```

Arguments

speech	Either a numeric vector providing E_i', the equivalent speech spectrum level (in dB) at each frequency, or a character string indicating the stated vocal effort corresponding to one of the standard standard speech spectrum levels ("normal", "raised", "loud", "shout"). Defaults to `speech="normal"` correspoding to the normal level of stated vocal effort.
noise	A numeric vector providing N_i', the equivalent noise spectrum level (in dB) at each frequency. If missing, defaults to -50 dB for each frequency.
threshold	A numeric vector providing T_i', the equivalent hearing threshold level (in dB) at each frequency. If missing, defaults to 0 dB for each frequency.
loss	A numeric vector providing J_i', the conductive hearing loss level (in dB) at each frequency. If missing, defaults to 0 dB for each frequency.

freq	Vector of frequencies for which speech, noise, threshold, and/or loss are specified. If interpolate=TRUE, freq must be specified. Otherwise, it must either match the required value for SII calculation method given by argument method, or be missing, in which case it will default to the values required for the specified method.
method	A character string specifying the SII calculation method ("critical", "one-third octave", "equal-contributing", "octave")
importance	Either a numeric vector providing F_i, the transfer function (importance weights) at each frequency, or a character string indicating which transfer function to employ ("SII", "NNS", "CID22", "NU6", "DRT", "ShortPassage", "SPIN", "CST"). Defaults to the standard SII transfer function, importance="SII".
interpolate	Logical flag indicating whether to interpolate from the provide measurement values and frequencies to those required by the specified method via linear interpolation on the log scale.
object,x	SII object
digits	Number of digits to display
...	Optional arguments to print, summary, and plot methods

Details

American National Standard ANSI S3.5-1997 ("Methods for Calculation of the Speech Intelligibility Index") defines a method for computing a physical measure that is highly correlated with the intelligibility of speech as evaluated by speech perception tests given a group of talkers and listeners. This measure is called the Speech Intelligibility Index, or SII. The SII is calculated from acoustical measurements of speech and noise.

The sii function implements ANSI S3.5-1997 as described in the standard, without any attempt to optimize the performance. The implementation does, however, include the extension for handling conductive hearing loss from Annex A (utilizing the optional loss argument), and for utilizing alternative band weights (i.e. transfer function) appropriate for differing message contents (e.g. types of speech) as described in Annex B or user-specified band weights (utilizing the optional argument importance).

Further, this implementation provides a mechanism for interpolating/extrapolating available measurements to those required for the specified calculation procedure. When interpolate=TRUE, required values for speech, noise, threshold, and loss will be computed using linear interpolation (of the log-scaled data). In this case, missing values may be provided and will be appropriately interpolated.

Value

The return value is an object of class SII, containing the following components:

call	Function call used to generate the SII object
orig	List containing original (pre-extrapolation) values for freq, speech, noise, threshold, and loss.
speech, noise, threshold, loss, and freq	Values used in calculations (extrapolated if necessary)

`table` SII calculation worksheet, containing columns corresponding to both Table C.1 and C.2 in Annex C of the standard. Table columns are

- **Fi** Center frequency of SII band, Hz
- **E'i** Spectrum level of equivalent speech, dB
- **N'i** Spectrum level of equivalent noise, dB
- **T'i** Equivalent hearing threshold level, dB
- **Vi** Spectrum level for self-speech masking, dB
- **Bi** Larger of the specrum levels for equivalent noise and self-speech masking, dB
- **Ci** Slope per octave (doubling of frequency) of the upward spread of masking, dB/octave
- **Zi** Spectrum level for equivalent masking, dB
- **Xi** Spectrum level of internal noise, dB
- **X'i** Spectrum level of equivalent internal noise, dB
- **Di** Spectrum level for equivalent disturbance, dB
- **Ui** Spectrum level of standard speech for normal vocal effort, dB
- **Ji** Equivalent hearing threshold due to conductive hearing loss, dB
- **Li** Speech level distortion factor, dB
- **Ki** Temporary variable used in the calculation of the band auditability function
- **Ai** Band auditability function
- **Ii** Band importance function
- **IiAi** Product of the band importance function (Ii), and band auditability function(Ai)

`sii` Calculated SII value

Author(s)

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References

ANSI S3.5-1997, "American National Standard Methods for Calculation of the Speech Intelligibility Index" American National Standards Institute, New York.

Other software programs for calculating SII are available from http://www.sii.to/html/programs.html.

See Also

SII Constants: `critical`, and `sic.critical`

Examples

```
## Example C.1 from ANSI S3.5-1997 Annex C
sii.C1 <- sii(
             speech   = c(50.0, 40.0, 40.0, 30.0, 20.0,  0.0),
```

```
              noise    = c(70.0, 65.0, 45.0, 25.0,  1.0,-15.0),
              threshold= c( 0.0,  0.0,  0.0,  0.0,  0.0,  0.0),
              method="octave"
      )
sii.C1                        # rounded to 2 digits by default
print(sii.C1$sii, digits=20)  # full precision
summary(sii.C1)               # full details
plot(sii.C1)                  # plot
## The value given in the Standard is $0.504$.



## Same calculation, but manually specify the frequencies
## and importance function, and use default for threshold

sii.C1 <- sii(
              speech   = c(50.0, 40.0, 40.0, 30.0, 20.0,  0.0),
              noise    = c(70.0, 65.0, 45.0, 25.0,  1.0,-15.0),
              method="octave",
              freq=c(250, 500, 1000, 2000, 4000, 8000),
      importance=c(0.0617, 0.1671, 0.2373, 0.2648, 0.2142, 0.0549)
      )
sii.C1

## Now perform the calculation using frequency weights for the Connected
## Speech Test (CST)
sii.CST <- sii(
               speech   = c(50.0, 40.0, 40.0, 30.0, 20.0,  0.0),
               noise    = c(70.0, 65.0, 45.0, 25.0,  1.0,-15.0),
               method="octave",
       importance="CST"
      )
round(sii.CST$table[,-c(5:7,13)],2)
sii.CST$sii

## Example C.2 from ANSI S3.5-1997 Annex C

sii.C2 <- sii(
              speech   = rep(54.0, 18),
              noise    = c(40.0, 30.0, 20.0, rep(0, 18-3) ),
              threshold= rep(0.0,  18),
              method="one-third"
              )
sii.C2$table[1:3,1:8]
sii.C2

## Interpolation example, for 8 frequencies using NU6 importance
## weight, default values for noise.
sii.left <- sii(
               speech="raised",
               threshold=c(25,25,30,35,45,45,55,60),
               freq=c(250, 500, 1000, 2000, 3000, 4000, 6000, 8000),
               method="critical",
```

```
                  importance="NU6",
                  interpolate=TRUE
                  )
    sii.left
```

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