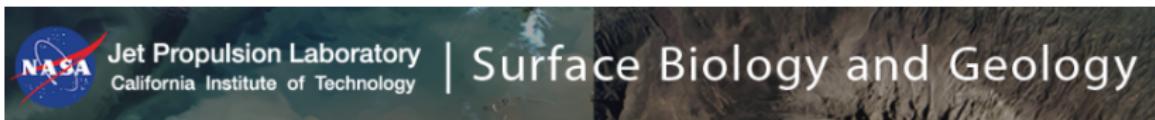


Like Mozart in the Nostromo starship: relaxing the xenomorphic nature of colors for colorblind people

Duccio Rocchini
Alma Mater Studiorum University of Bologna
Czech University of Life Sciences

Talk held online at:



Background: the issue
●○○○○○○○

How to solve the issue?
○○○○○○○○○○

Challenges
○○○○○○○

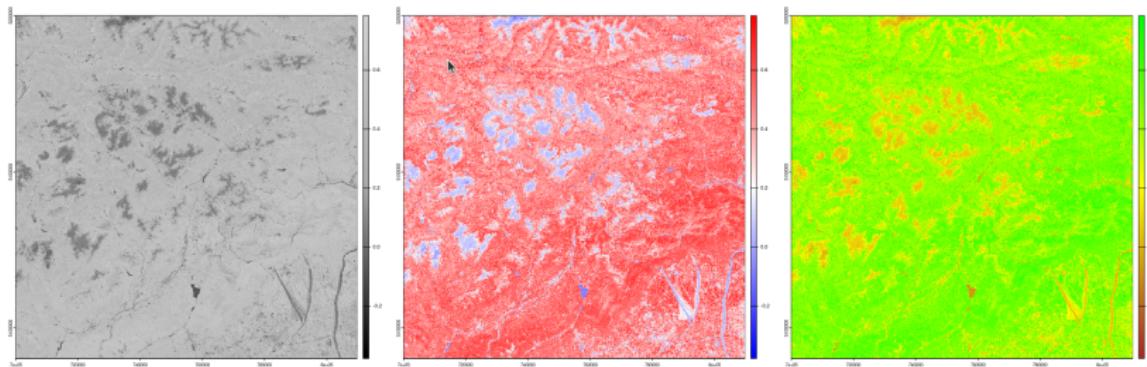
Outline

1 Background: the issue

2 How to solve the issue?

3 Challenges

Perception of reality through colors



Aim

- Introducing the issue of **colorblindness** in remote sensing data outputs
- Proposing algorithms to **solve the issue** in a straightforward manner

Free and Open Source Software



Letter

Cell
PRESS

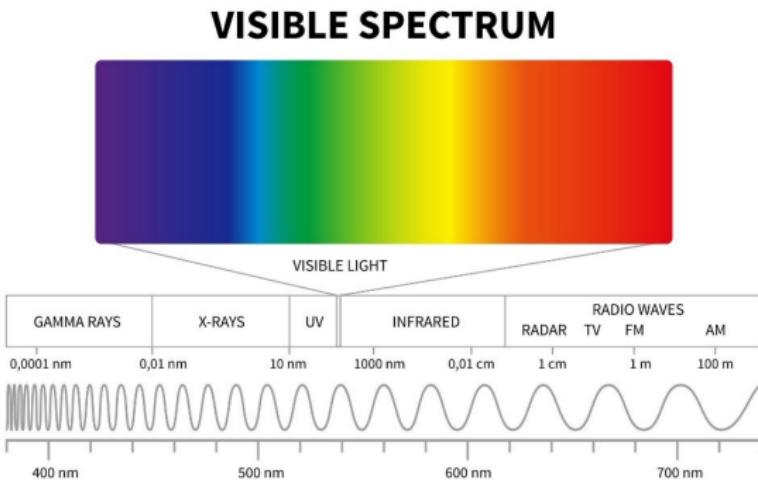
Let the four freedoms paradigm apply to ecology

Duccio Rocchini and Markus Neteler

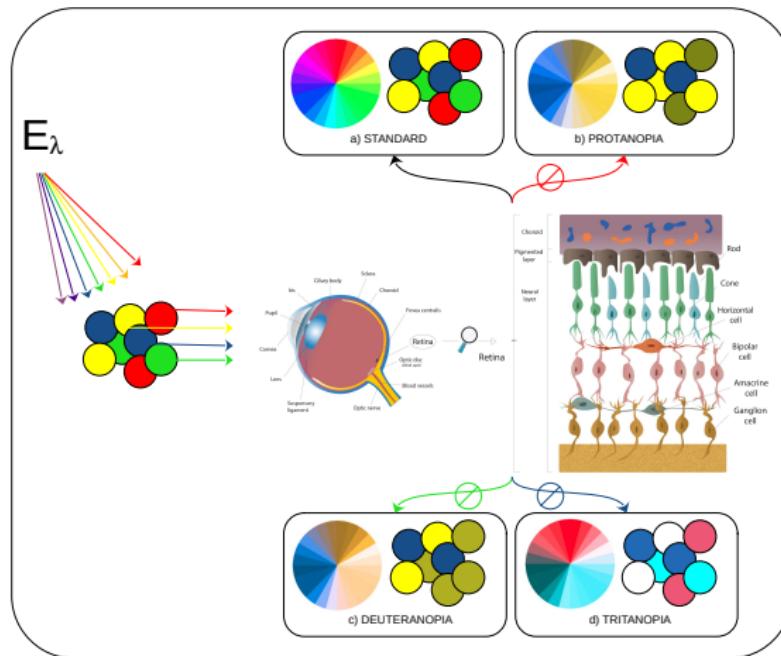
Fondazione Edmund Mach, Research and Innovation Centre, Department of Biodiversity and Molecular Ecology, Via E. Mach 1,
38010 S. Michele all'Adige (TN), Italy

In our view, the explicit use of Free and Open Source Software (FOSS) with **availability of the code** is essential for **completely open science**: 'scientific communication relies on evidence that cannot be entirely included in publications', but '**anything less than the release of source programs is intolerable for results that depend on computation**' [3].

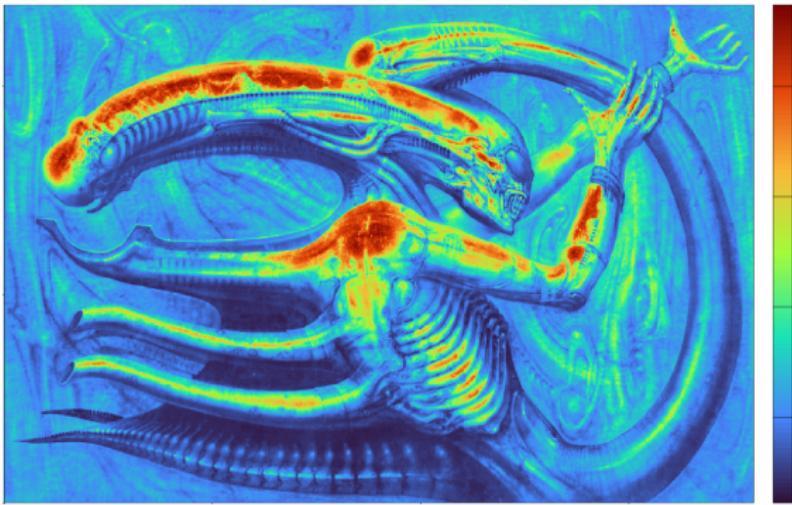
Colors in the electromagnetic spectrum



Daltonism

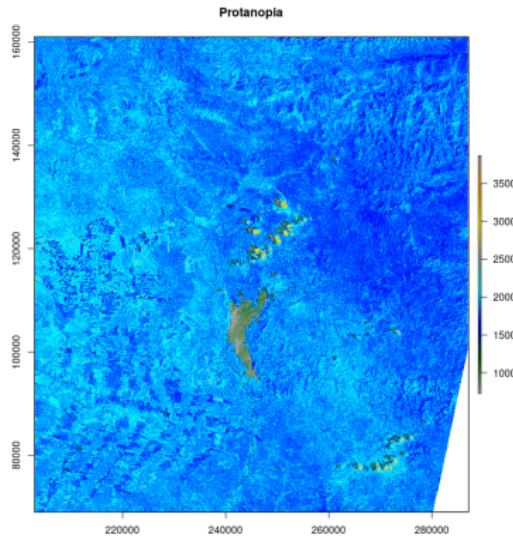
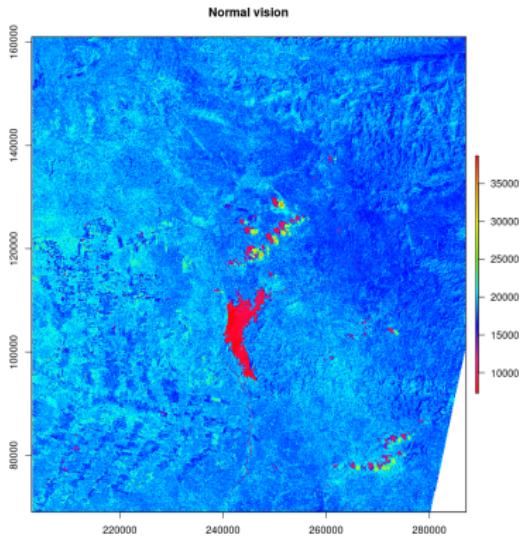


Colors for colorblind people can lead to an “alien” perception of reality



Redrawn from: Hans Ruedi Giger, Necronom IV, 1976.

Rainbow color palettes in scientific papers

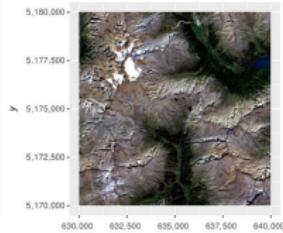


Rainbow color palettes in scientific papers

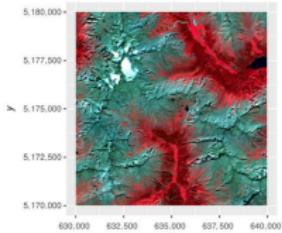
In situ image



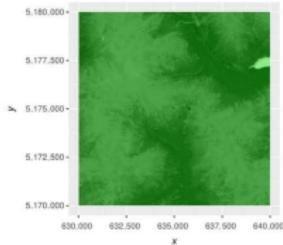
Natural colours (Sentinel-2, 10 m)



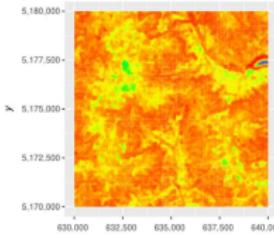
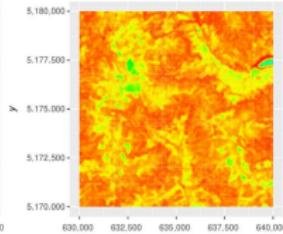
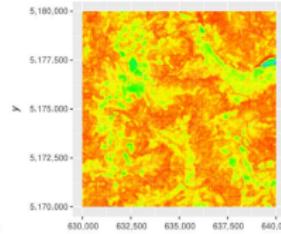
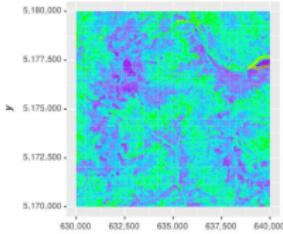
False colours (Sentinel-2, 10 m)



NDVI



Value
-1.0 -0.5 0.0 0.5

Rényi's entropy ($\alpha = 0$)Rényi's entropy ($\alpha = 1$) | Shannon's H Rényi's entropy ($\alpha = 5$)Rao's Q 

Value
1 2 3 4

Value
1 2 3 4

Value
1 2 3 4

Value
0 30 60 90

Rocchini et al. (Methods Ecol. Evol., 2023)

Background: the issue
ooooooooo

How to solve the issue?
●ooooooooo

Challenges
ooooooo

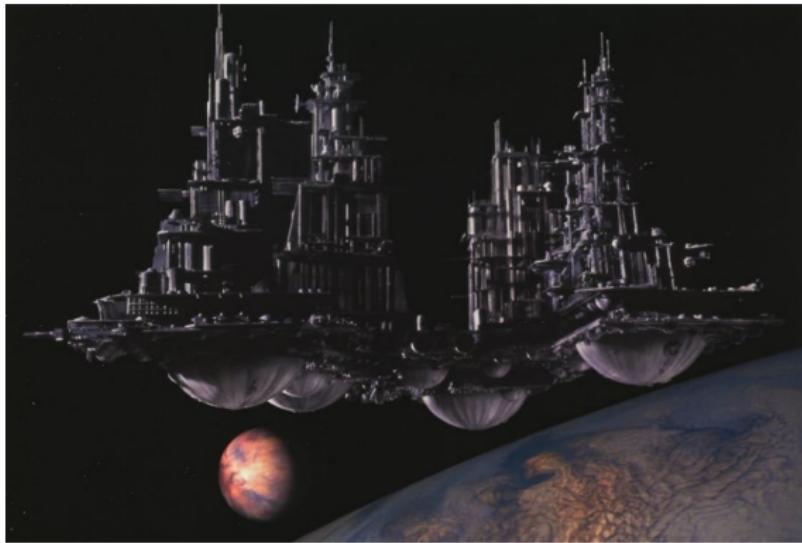
Outline

1 Background: the issue

2 How to solve the issue?

3 Challenges

Like Mozart in the Nostromo starship



<https://www.youtube.com/watch?v=oy2zDJPIgwC>
Wolfgang Amadeus Mozart (1756-1791) - Eine Kleine Nachtmusik

Cramieri et al. - Misuse of colors



PERSPECTIVE

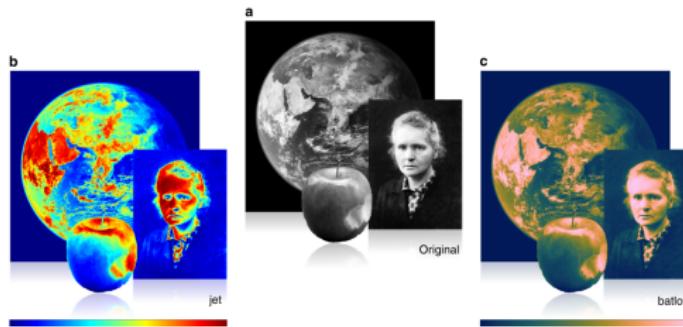
<https://doi.org/10.1038/s41467-020-19160-7>

OPEN

Check for updates

The misuse of colour in science communication

Fabio Crameri¹, Grace E. Shephard¹ & Philip J. Heron²



The viridis R package



<https://CRAN.R-project.org/package=viridis>

The viridis R package



<https://CRAN.R-project.org/package=viridis>

Color blindness



Duccio Rocchini @ducciorocchini · 13 apr 2023
A new package to let colour blind people see all maps!

...

Available in GitHub: [github.com/ducciorocchini...](https://github.com/ducciorocchini/cblindplot)

Install it by: `install.packages("devtools")
devtools::install_github("ducciorocchini/cblindplot")`
And here is the description: [doi.org/10.1016/j.ecolinf...](https://doi.org/10.1016/j.ecolinf.2023.103931)



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journal homepage: www.elsevier.com/locate/ecolinf



Scientific maps should reach everyone: The `cblindplot` R package to let colour blind people visualise spatial patterns

Duccio Rocchini ^{a,b,*}, Jakub Nowosad ^{c,1}, Rossella D'Intronzo ^d, Ludovico Chieffallo ^a,
Giovanni Bacaro ^e, Roberto Cazzolla Gatti ^a, Giles M. Foody ^f, Reinhard Furrer ^{g,h}, Lukáš Gábor ^{i,j},
Marco Malavasi ^{b,k}, Matteo Marcantonio ^l, Elisa Marchetto ⁿ, Vítězslav Moudrý ^b, Carlo Ricotta ^m,
Petrá Šimová ^b, Michele Torresani ⁿ, Elisa Thouverai ^a



7



346



908

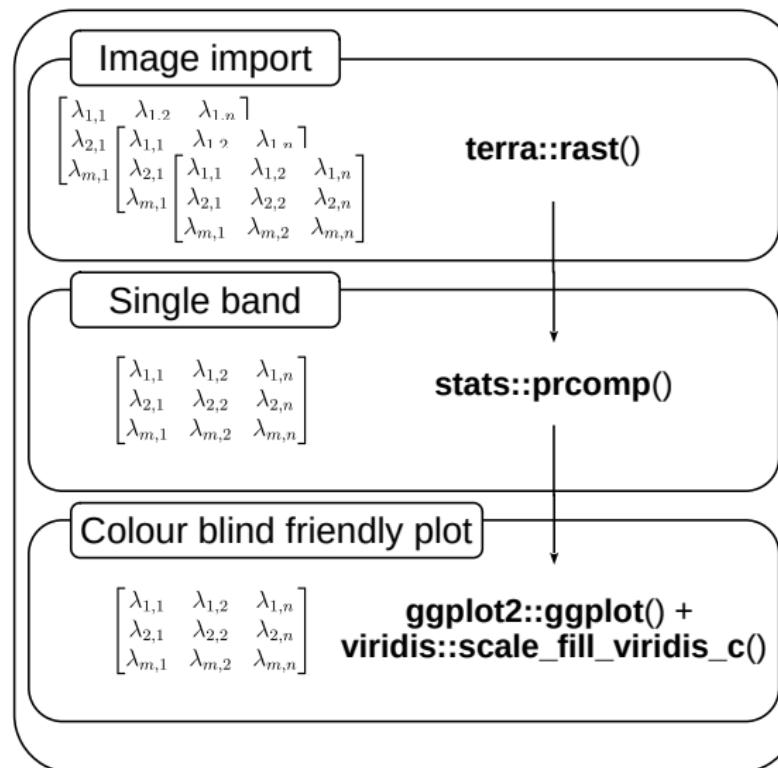


68.916



<https://github.com/ducciorocchini/cblindplot>

The algorithm



The cblind.plot() function

```
cblind.plot <- function(im,
  cvd=c("protanopia", "deutanopia", "tritanopia"),
  r=1, g=2, b=3,
  crop_manual=FALSE,
  selectclass=FALSE)
```

What do colorblind people see?

cryospheric components, including snow cover, permafrost and ice sheets, together with temperature data, to help detect the fingerprints² of greenhouse global warming.

Ola M. Johannessen*

Martin Miles

Einar Bjørø

Nansen Environmental and Remote

Sensing Center,

Edward Griegsvei 3a,

5037 Solheimsvik/Bergen, Norway

*Also at Geophysical Institute, University of Bergen, 5007 Bergen, Norway.

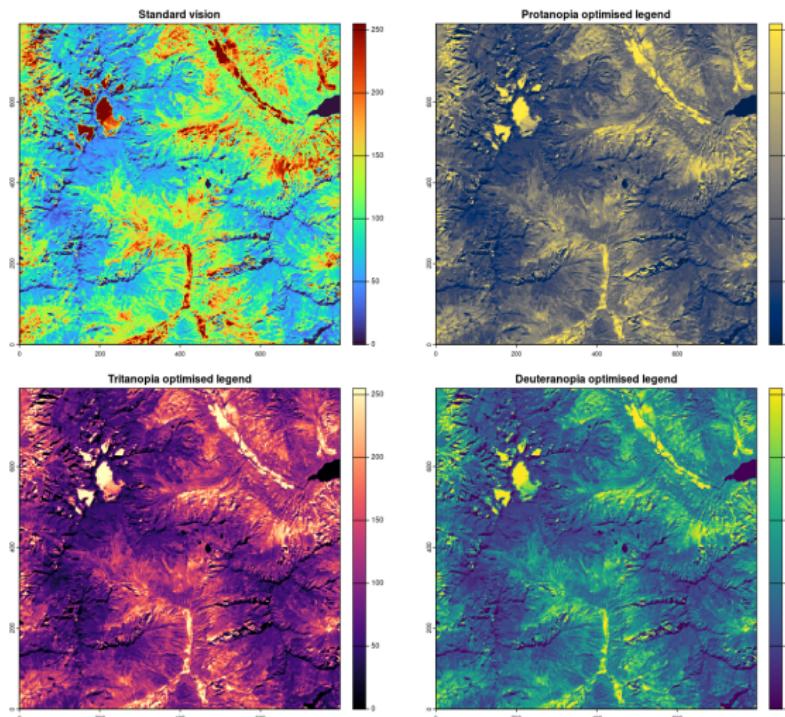
What do colour-blind people see?

SIR — Most human observers enjoy trichromatic vision: a three-dimensional colour space represents all the light that they can discriminate¹. Two per cent of the male population are dichromats, that is, they lack one class of photopigment and have a colour gamut that can be represented in a two-dimensional space. Here we offer to the normal trichromat a



Reproduction of the video monitor display that simulates the reduced colour gamut of dichromatic colour-defective observers. *a*, Photograph of the 'Jardin des Plantes' (photo: Jean Le Rohellec; Grande Galerie, FNAC). The contrast was reduced to allow for all three projections onto the reduced stimuli surfaces to exist. *b*, *c*, *d*, Simulations of how *a* is seen by a protanope, deutanope and tritanope, respectively. (A colorimetrically exact reproduction of the video display cannot be guaranteed in the printed version.)

The output



Background: the issue
oooooooooo

How to solve the issue?
oooooooooooo

Challenges
●oooooooo

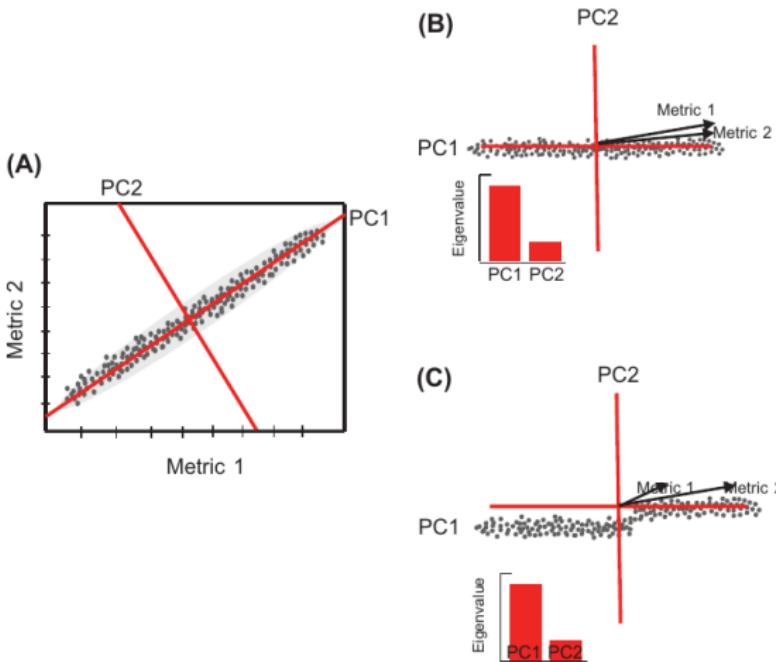
Outline

1 Background: the issue

2 How to solve the issue?

3 Challenges

PCA problems in managing minima and maxima



Nakamura et al. (Ecography, 2020)

Background: the issue
○○○○○○○○○

How to solve the issue?
○○○○○○○○○○

Challenges
○○●○○○○

Neural networks



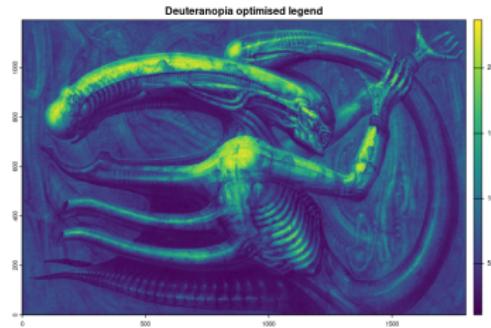
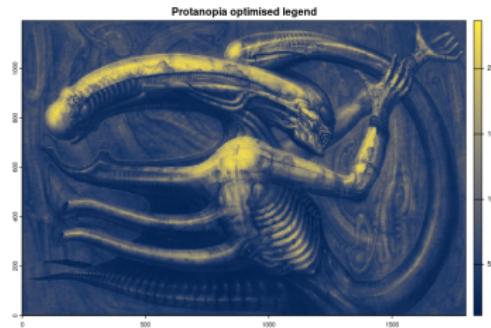
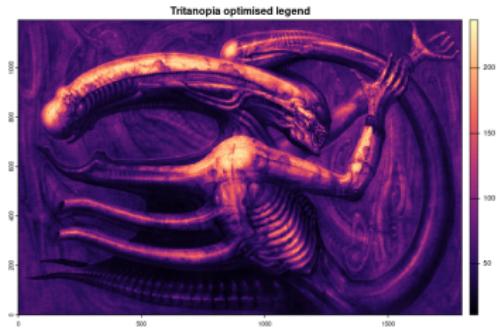
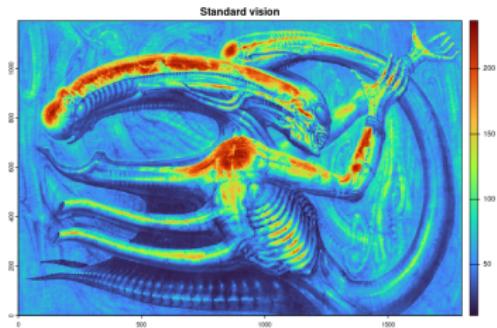
The nncblind neural networks algorithm

The screenshot shows a GitHub repository interface for the 'cblindplot' project. The left sidebar lists files: main, .github, R (including cbind.plot.R, sysdata.rda, cbindplot-package.R, and nncblind.R), data Raw, inst, man, vignettes, .Rbuildignore, .gitignore, DESCRIPTION, LICENSE.md, NAMESPACE, README.Rmd, and README.md. The right pane displays the content of nncblind.R. The code defines a function nncblind that takes an image (im) and a cvd vector. It checks if cvd contains 'protanopia', 'deuteranopia', or 'tritanopia'. If not, it stops with an error message. Then, it checks if im is a raster object, a list, or a path to an image. If not, it issues a warning. If im is a character, it converts it to a list. Finally, it checks if im is a SpatRaster. If not, it stops with an error message. If im is a SpatRaster, it creates a data frame df from it, adds columns for R, G, and B, and then converts the values to characters. The GitHub interface includes a search bar, a code editor with syntax highlighting, and a status bar indicating 'OcaBac9 · last week'.

```
1  nncblind <- function(im, cvd = c("protanopia", "deuteranopia", "tritanopia"), r = 1, g = 2, b = 3) {  
2  
3      #Controllo cvd  
4      cvd <- cvd[1]  
5      if(!cvd %in% c("protanopia", "deuteranopia", "tritanopia")) stop("Wrong 'cvd' value. It can be 'protanopia', 'deuteranopia', or 'tritanopia'")  
6  
7      #Controllo Immagine  
8      if (!inherits(im, "SpatRaster") && !inherits(im, "RasterLayer") && !inherits(im, "RasterStack") && !inherits(im, "RasterBrick") && !inherits(im, "list") && !is.character(im)) stop("im" must be a raster object, a list or a path to an image")  
9      else if (!inherits(im, "MasterLayer") || inherits(im, "RasterStack") || inherits(im, "RasterBrick") || is.character(im)){  
10          suppressWarnings(im <- terra::rast(im))  
11      } else if (inherits(im, "list")){  
12          invisible(lapply(im, function(x) if(!inherits(x, "SpatRaster")) stop("all the elements of the list must be SpatRaster objects")))  
13          suppressWarnings(im <- terra::rast(im))  
14      }  
15  
16      # Preparazione dati  
17      df <- as.data.frame(im, xy = T)  
18      df_mod <- data.frame(df[,1], df[,2], df[, (r + 2)], df[, (g + 2)], df[, (b + 2)])  
19      colnames(df_mod) <- c("x", "y", "R", "G", "B")  
20  
21      # Convertire in caratteri i valori delle colonne R, G, B al fine di rendere compatibili con il modello nnet  
22      df_mod <- df_mod %>% mutate(R = as.character(R), G = as.character(G), B = as.character(B))
```

<https://github.com/ducciorocchini/cblindplot/blob/main/R/nncblind.R>

Coda



Coda

Ecological Informatics 76 (2023) 102045



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Petrá Šimová^b, Michele Torresaniⁿ, Elisa Thouverai^a



Many thanks!



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Contact:

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Alma Mater Studiorum University of Bologna, Italy

duccio.rocchini@unibo.it - <https://www.unibo.it/sitoweb/duccio.rocchini/en>



This presentation has been made by only relying on Free and Open Source philosophy: Linux, L^AT_EX, R, GRASS GIS.

