Geometric morphometrics

Geometric morphometric data gathering

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Section 1

Introduction

The types of geometric morphometric data

True landmarks

- Landmarks are points that are well defined in all specimens
- Three types of landmarks can be distinguished

The types of geometric morphometric data

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The types of geometric morphometric data

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The types of geometric morphometric data

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  2. **Mathematical landmarks:** Defined on the basis of geometric properties
     1. **Type II landmarks:** Points that are defined by a local property, such as maximum curvature of the shell
     2. **Type III landmarks:** Landmarks at extremal points of a structure (e.g. the tip of the finger bone) or at constructed points (e.g. the centroid of the eye cavity)

The types of geometric morphometric data

Landmarks example

The types of geometric morphometric data

Landmarks example

- **Type I**

The types of geometric morphometric data

Landmarks example

The types of geometric morphometric data

Landmarks example

The types of geometric morphometric data

Semi-landmarks

- Constructed points along a structure
- Sometimes used in conjunction with landmarks
  - A fixed number of equally-distant constructed points along a structure between two anatomical or mathematical landmarks
  - Can be used to increase the number of morphological information when few well-defined landmarks are available

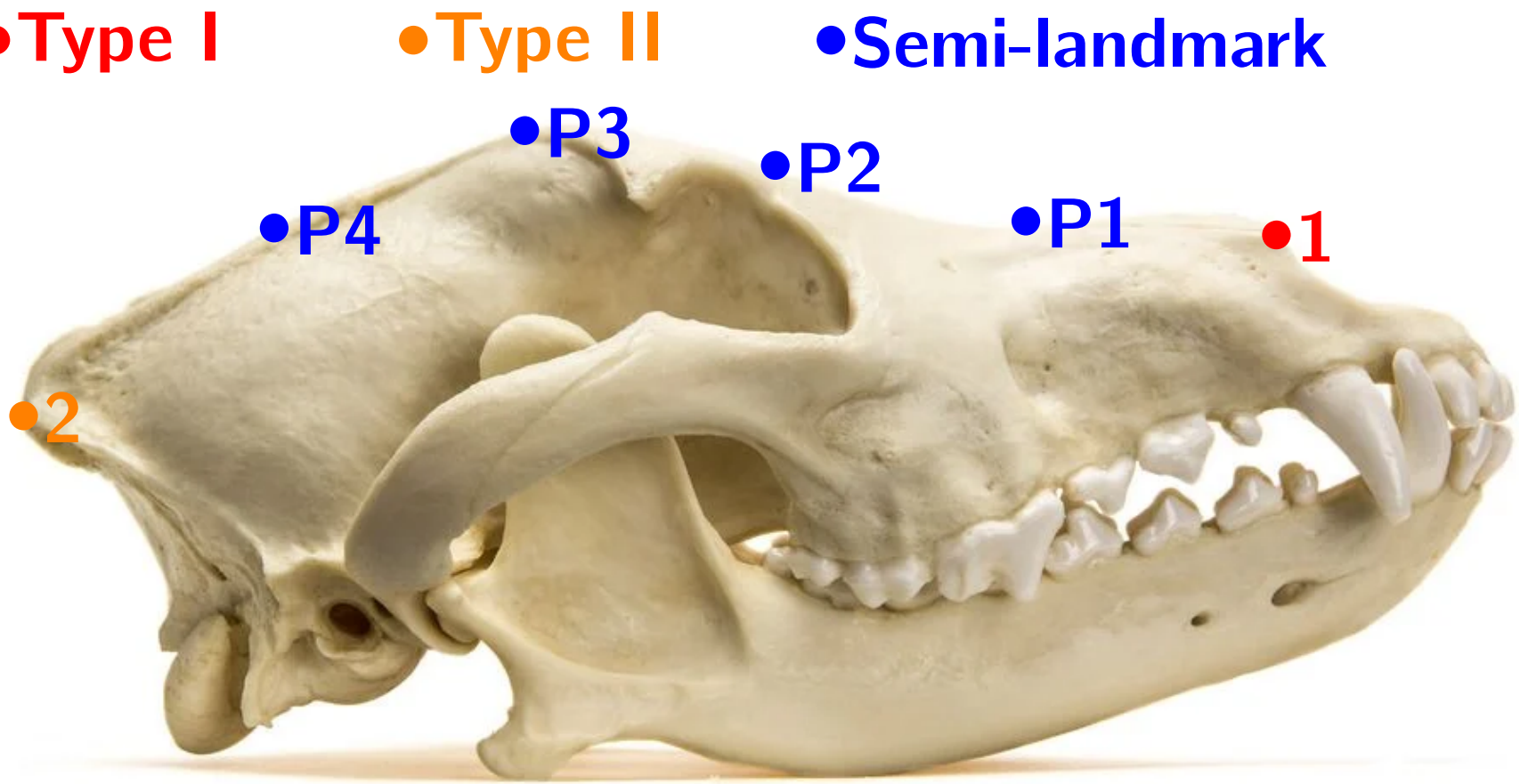
The types of geometric morphometric data

Semi-landmarks example 1

- **Type I**
- **Type II**

The types of geometric morphometric data

Semi-landmarks example 1



The types of geometric morphometric data

Semi-landmarks

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- Sometimes used in conjunction with landmarks
  - A fixed number of equally-distant constructed points along a structure between two anatomical or mathematical landmarks
  - Can be used to increase the number of morphological information when few well-defined landmarks are available
- Most frequently used to gather date for outline analysis
  - A fixed number of equally-distant constructed points along a structures outline, starting and ending at a well-defined and homologous outline starting point
  - Used as basis for mathematical re-description of the outline

The types of geometric morphometric data

Semi-landmarks example 2

The types of geometric morphometric data

Semi-landmarks example 2

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Semi-landmarks example 2

Semi-landmarks

-Equal distance

-Same number

The types of geometric morphometric data

Semi-landmarks example 2

Semi-landmarks

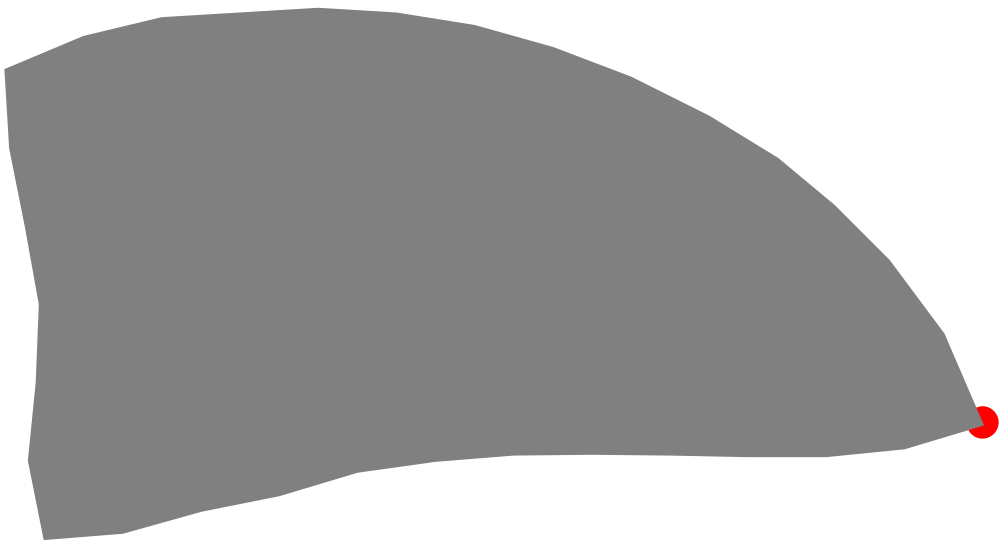
-Equal distance

-Same number

-Same direction

The types of geometric morphometric data

Semi-landmarks example 2



Semi-landmarks

-Equal distance

-Same number

-Same direction

Section 2

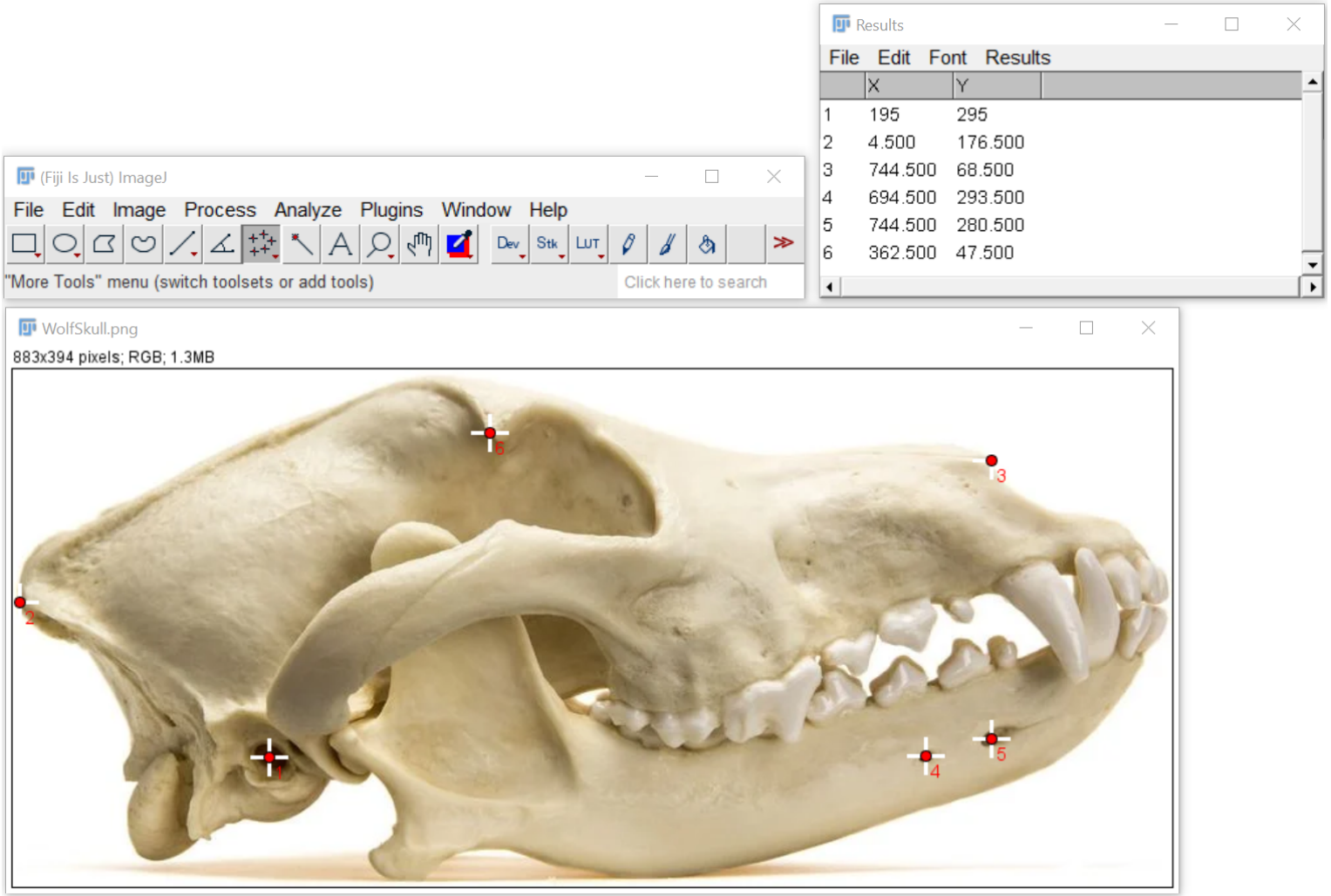
Data extraction software

FIJI

- Extended distribution of ImageJ
- General purpose scientific image analysis software
- Well usable for **landmark extraction**
- Technically usable for outline extraction, but no possibility to choose starting point and no easy way to extract outline coordinates by default
- Data per specimen saved in separate tables (no morphometric file-type support by default)
- Constantly updated, lively community, customizable (JavaScript)
- `https://imagej.net/software/fiji/`

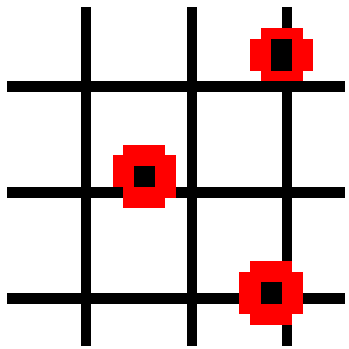
FIJI

Example of landmark coordinate extraction



tpsDig2

- Specialized morphometrics extraction program
- **Landmarks mode** allows to manually extract landmarks (first configuration can be used as template for following specimens)
- **Outlines mode** allows to extract an outline from an object (via thresholding) with manually user-defined starting point
- Data can be saved in `.tps`- or `.nts`-format
- No customization, kept alive and updated by James Rohlf (currently 85 years old)
- `http://sbmorphometrics.org/soft-dataacq.html`

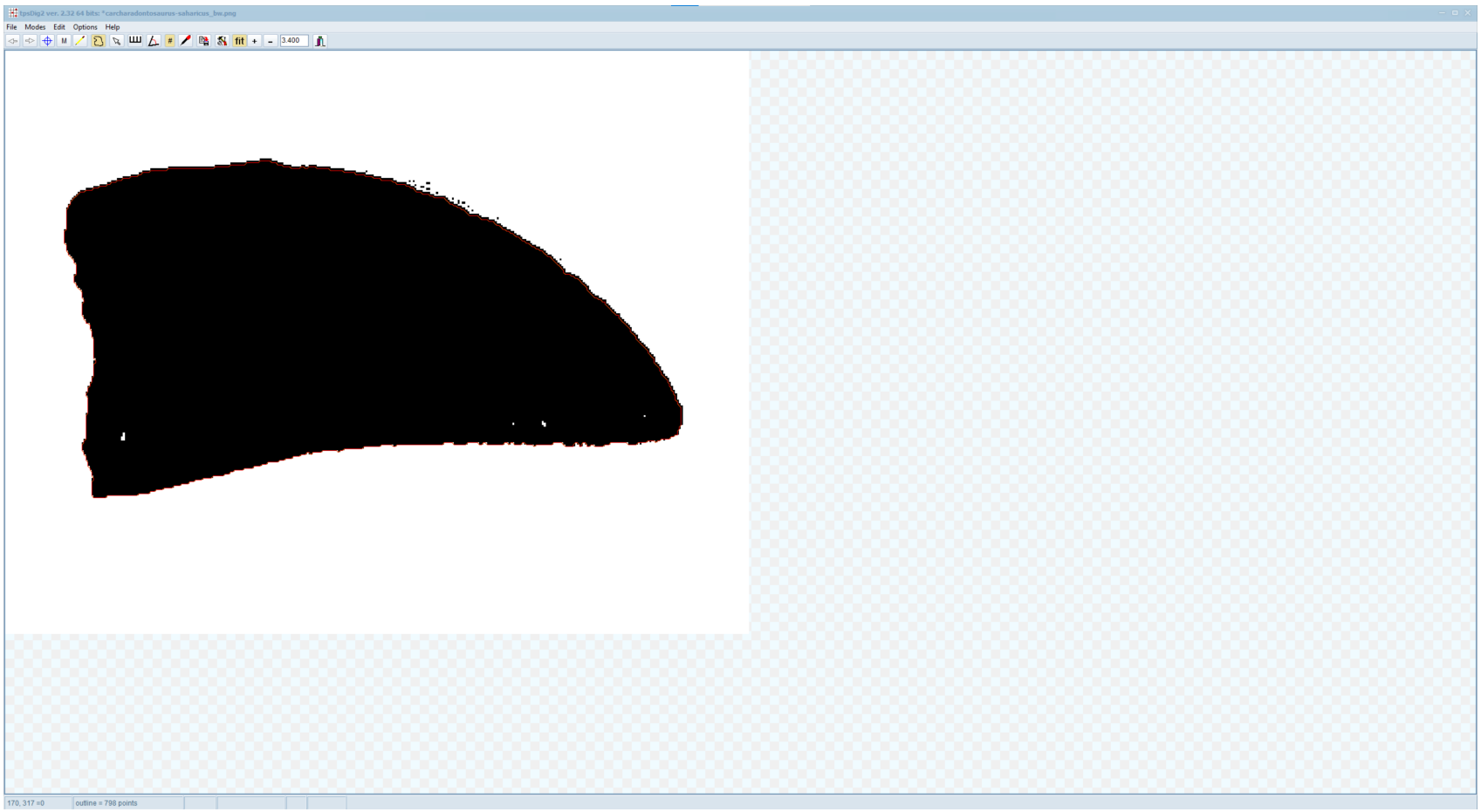


tpsDig2

Example of landmark coordinate extraction

tpsDig2

Example of outline coordinate extraction



R

- All-purpose statistical programming language
- Image capabilities useful for extraction of both **landmark** and **outline** coordinates
- Different image file types are supported (`.ppm` file format functionality most consistently survives updates to the R-core engine)
- Extracted data can be exported in `.tps`- or `.nts`-format or any other desired format by writing the necessary code
- Constantly updated, lively community, fully customizable
- `https://cran.r-project.org/`

R

Example of landmark and outline coordinate extraction

For a short look at morphometric data extraction in R, we move on to exercise № 1

Open the exercise sheet for instructions and code examples