Application of statistical shape analysis to the classification of renal tumours appearing in childhood

M.A./Dipl. Math. /Cand. Soz. päd.
Stefan Markus Giebel
Stefan.Giebel@t-online.de
Université du Luxembourg Campus Limpertsberg
Dr. J.P.-Schenk Uniklinikum Heidelberg
Prof. Dr. J. Schiltz, Uni Luxembourg

Overview

1) Survey

2) Shape

3) Mean Shape

4) Tests

5) Classification
- Conclusion
- Forecast

Renal tumours appearing in early childhood

- Renal tumours in childhood are classified in three stages of malignancy (I,II,III).
In stage II different subtypes of tumour tissue exist.
The majority of renal tumours are nephroblastoma (Wilms´tumours)
high sensitivity for chemotherapy

- Renal cell carcinoma are vary rare in childhood
typical tumours in adult patients
no sensitivity for chemotherapy

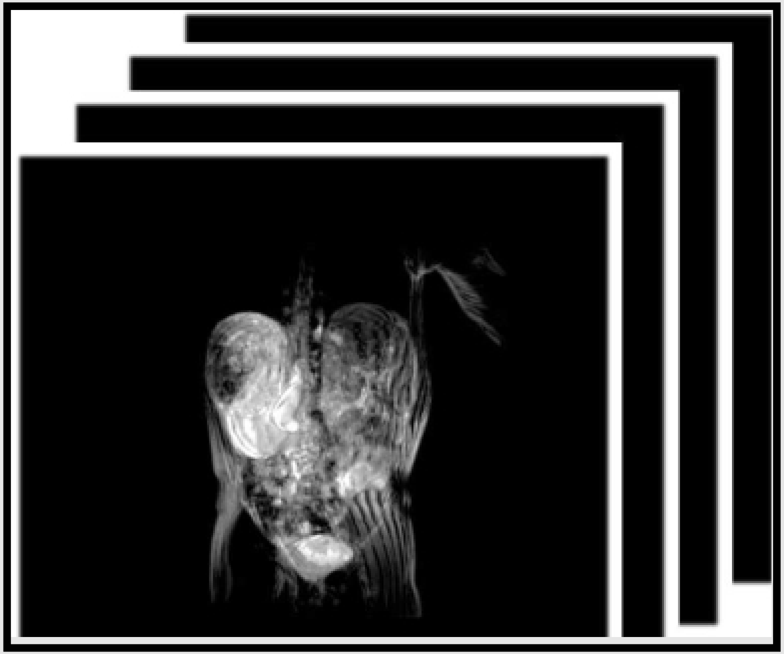
- Clear cell sarcoma
very rare tumour in childhood
high malignancy

- Neuroblastoma is the main differential diagnosis to nephroblastoma
typical tumour of sympathetic nervous system and suprarenal glands
tumour growth with encasement of vessels

Every kind of tumour needs its therapy.

Dicom Data

Main diagnostic tools are sonography, CT and MRI. Because MRI has no radiation exposure it is the preferred radiological method. Depending on radiological diagnosis therapy or biopsy is planned and organised in study protocolls of the SIOP (international society of pediatric hematology and oncology)

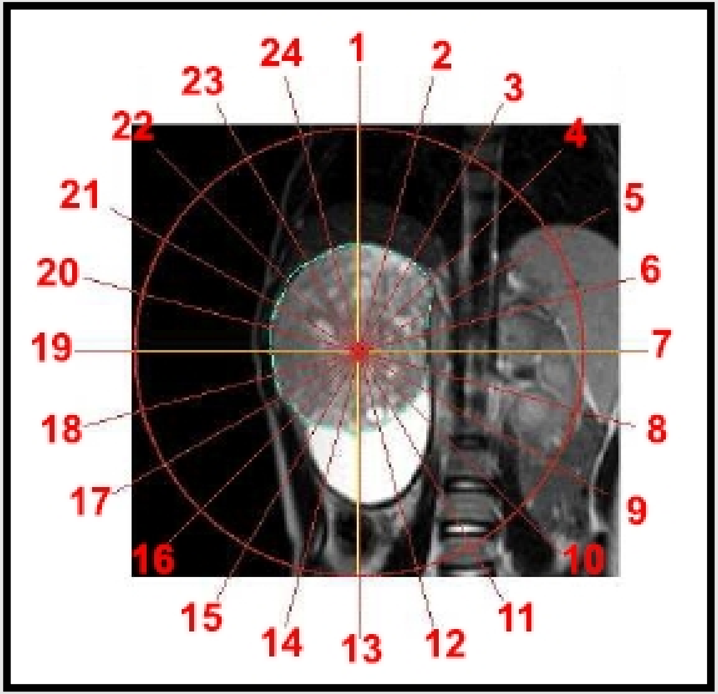


Getting transversal and frontal images of the tumour
Problem: Not for each patient we have both views
Images created by Magnetic resonance tomography

Three-dimensional object

1. Construction by using the data (density, depth etc.)

Explorative* survey of landmarks

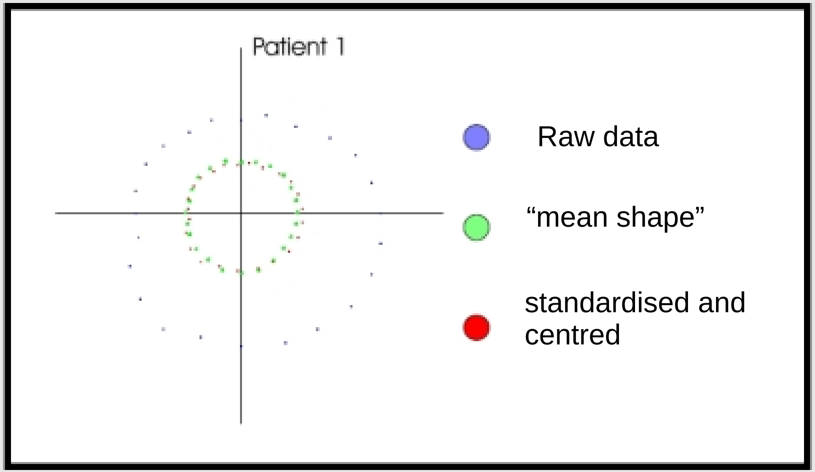


*there are no theoretical landmarks or theories about shape

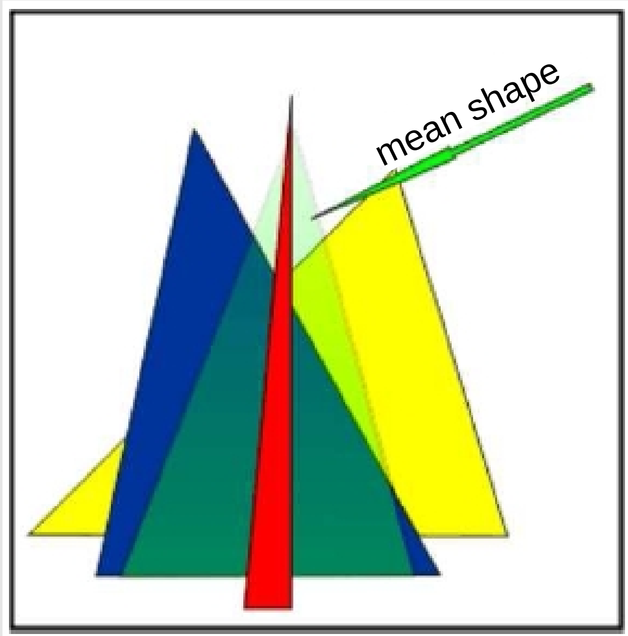
1. Determining of three dimensional mass point
2. Taking two dimensional image including the mass point

Data process

1. Standardisation (using Euclidean norm)
2. Centring on two-dimensional centre

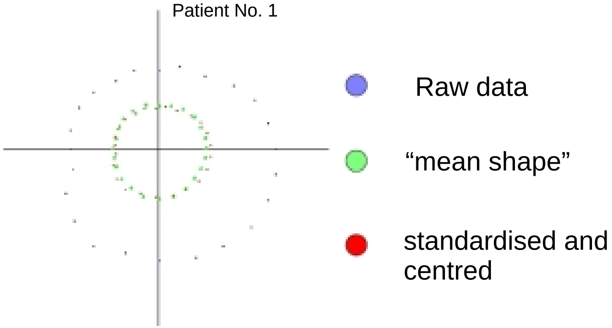


Determining of „mean shape“



Determining the expected “mean shape” of a group of objects.
That mean's: <u>smallest distance in the average to all shapes in the group</u>

Determing of “mean shape”



Using the following algorithm

$$i = 1, \dots, n$$

$$\bar{m} \mapsto w_i(\bar{m}) = \begin{cases} \frac{\langle \bar{m}, o_i \rangle}{|\langle \bar{m}, o_i \rangle|} & \text{if} \quad \langle \bar{m}, o_i \rangle \neq 0 \\ 1 & \text{if} \quad \langle \bar{m}, o_i \rangle = 0 \end{cases}$$

$$\bar{m} \mapsto T(\bar{m}) = \frac{1}{n} \sum_{i=1}^{n} w_i(\bar{m}) o_i$$

recursively there is a sequence

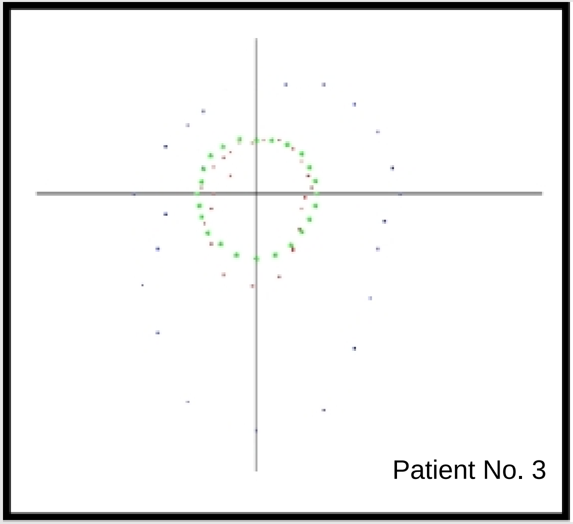
$\bar{m}_r = T(\bar{m}_{r-1}), r = 1, 2, \dots$ iterations

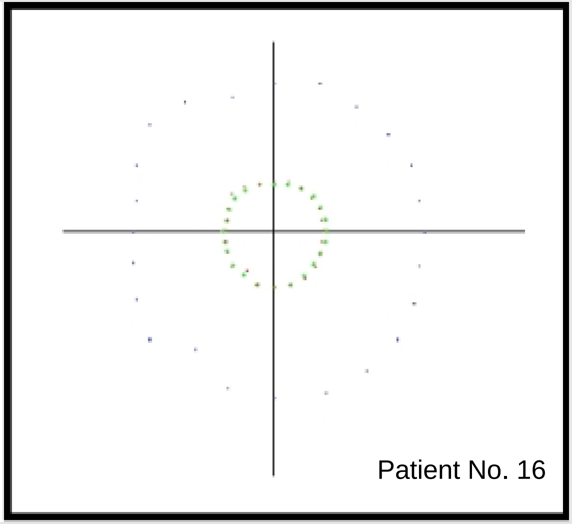
criterion to stop

$$\bar{m} = T(\bar{m})$$

Algorithm for „mean shape“ (Ziezold 1994)

Determining of „mean shape“





Statement: Patient 3 is very far from the “mean shape”.
Patient 16 is very near to the “mean shape“.

Distance from the “mean shape” (Wilms)

patient		distance	
Nr.	Diagnose	d_f	$rang_W$
Nr.1	n.b.	0.0849	3
Nr.2	IId	0.1009	6
Nr.3	IIc	0.2260	18
Nr.4	IIIa	0.0968	5
Nr.5	IIa	0.1567	13
Nr.6	IIb	0.1113	8
Nr.7	IId	0.1940	17
Nr.8	IId	0.1448	12
Nr.9	IId	0.1854	16
Nr.10	IIc	0.1290	11
Nr.11	IIb	0.1834	15
Nr.12	IIa	0.0772	2
Nr.13	IIc	0.0916	4
Nr.14	IIc	0.1058	7
Nr.15	IIc	0.1126	9
Nr.16	n.b.	0.0541	1
Nr.17	IIa	0.1178	10
Nr.18	IIc	0.1754	14

Description of the test (Ziezold, 1994)

The group of m objects is an indepedent realisation of the distribution P and the other group of k objects an independent realisation of the distribution Q

Determining of p-value according to the test

H_o :P=Q

$H_{1:}$ **:** P<>Q

1. step: Determining of “mean shape”

2.step: Determining of distances to the “mean shape” and the u0 according to the Mann Whitney-U-Test

3.step: Determining all possible u-values separating the group (k+m) in two groups with m and k objects

4.step: Determining the rank of u_0 in the group of all u-values

5.step: p-value = r/N

6.step: Determining the p-values in the other direction. Determining “mean shape” in the group of m objects

Description of the test (Ziezold 1994)

High u_{o}-values means: A lot of cases - not used for the “mean shape”- has a smaller distance to the “mean shape” than the cases used for the “mean shape”

Low u_{o}-values means: Only a small number of cases - not used for the “mean shape”- has a smaller distance to the “mean shape” than the cases used for the “mean shape”

Determining of all possible permutations
possibilities

bbrr
rrbb ....
rbbr ....
brrb ....
brbr ....
rbrb

4!/ (2! 2!) = 6 possibilities

|All|/ (| $subset_1$ |! |$subset_2$|! = Number of all possibilities

Checking of differences between types of „Wilms“- tumours

Subsets		Differentiation					
Tumortyp 1	Tumortyp 2	u_0	$m_=$	$m_<$	$p - Intervall$	k	$\binom{15}{k}$
$Typ\ a$	$\overline{Typ\ a}$	0	57	0	[0.002, 0.125]	3	455
$\overline{Typ\ a}$	$Typ\ a$	21	14	338	[0.745, 0.774]	12	455
$Typ\ b$	$\overline{Typ\ b}$	2	22	64	[0.619, 0.819]	2	105
$\overline{Typ\ b}$	$Typ\ b$	9	5	37	[0.362, 0.409]	13	105
$Typ\ c$	$\overline{Typ\ c}$	6	17	431	[0.086, 0.090]	6	5005
$\overline{Typ\ c}$	$Typ\ c$	14	155	780	[0.156, 0.187]	9	5005
$Typ\ d$	$\overline{Typ\ d}$	17	52	970	[0.711, 0.749]	4	1365
$\overline{Typ\ d}$	$Typ\ d$	10	40	153	[0.113, 0.141]	11	1365

m= …: Number of cases with the same u-value
m<…: Number of cases with a lower u-value
The interval is a result of the smallest and the highest rank of u_o

Only tumours tissue in development stage II and type known

Checking of differences between different tumours

N1: Neuroblastoma
N2: Renal cell carcinoma
K: clear cell sarcoma

Subsets		Differentiation						
Tumortyp 1	Tumortyp 2	u_0	$m_=$	$m_<$	$p - Intervall$	k	n	$\binom{n}{k}$
Wilms	N1	12	47	122	[0.0924, 0.1271]	3	21	1330
N1	Wilms	15	36	834	[0.6271, 0.6541]	18	21	1330
Wilms	K	5	4	13	[0.0737, 0.0895]	2	20	190
K	Wilms	0	103	0	[0.0053, 0.5421]	18	20	190
Wilms	N2	11	3	11	[0.6667, 0.7778]	18	19	18
K	N1	0	7	0	[0.1, 0.7]	2	5	10
N1	K	1	2	5	[0.6, 0.7]	3	5	10
K	N2	0	3	0	[0.3333, 1]	2	3	3
N1	N2	1	2	1	[0.5, 0.75]	3	4	4

m= …: Number of cases with the same u-value
m<…: Number of cases with a lower u-value
The interval is a result of the smallest and the highest rank of u_o

Conclusions

Typ c and clear cell carcinoma have a tendency for differentiation

Neuroblastoma only in one direction

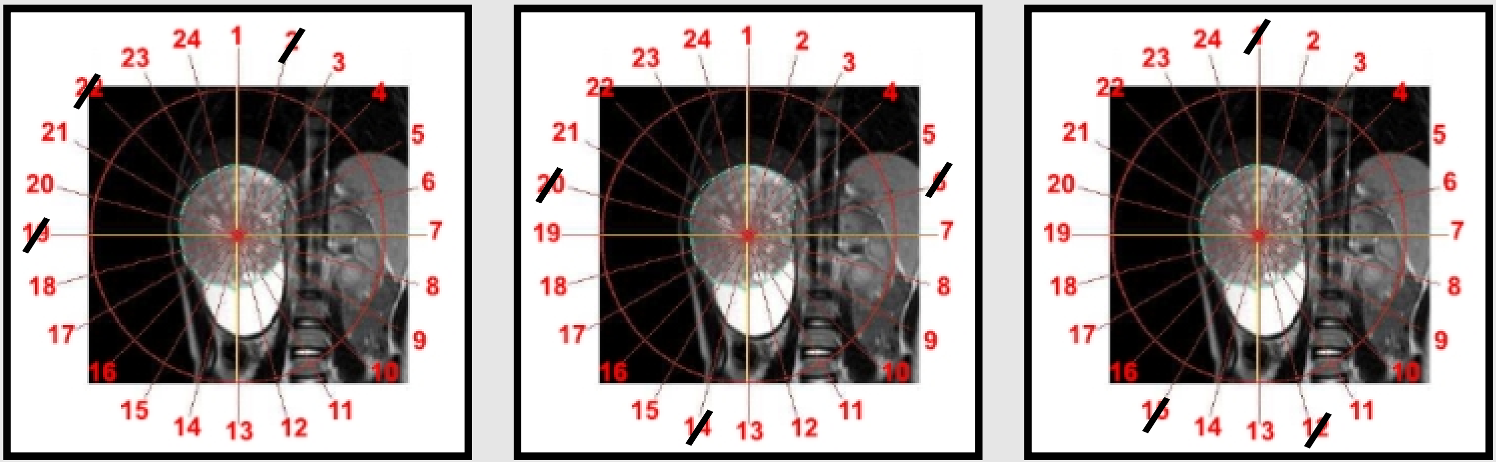
Renal cell carcinoma not differentiable

Forecast

Selection of landmarks

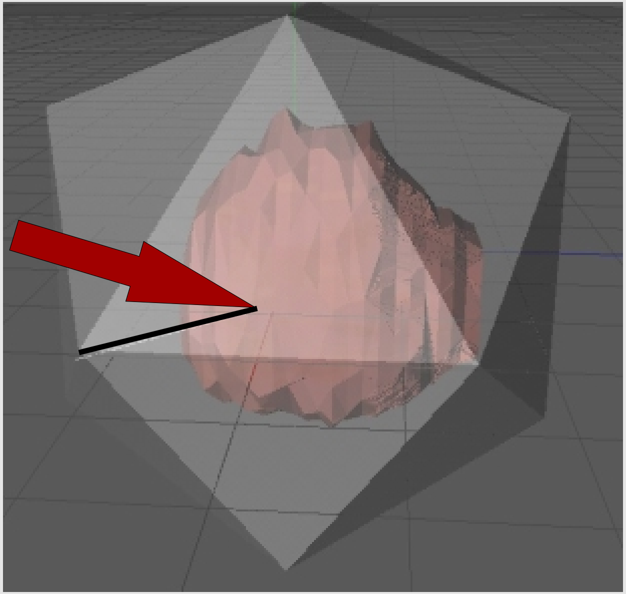
- Using only k of 24 landmarks
- Taking the best k-configuration for differentiation

Example: 21 of 24



Forecast

Determining of three dimensional landmarks



Teşekkür!

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