



FAKULTÄT FÜR
INFORMATIK



Visualization Group

Treatment-guided and Perception-based 3D Medical Visualizations

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- Visualizations for Treatment Planning
- Treatment-guided authoring system
- Perception-based user study
 - Experimental Setup
 - Experiment Conduction
 - Results and Analysis
- Conclusion

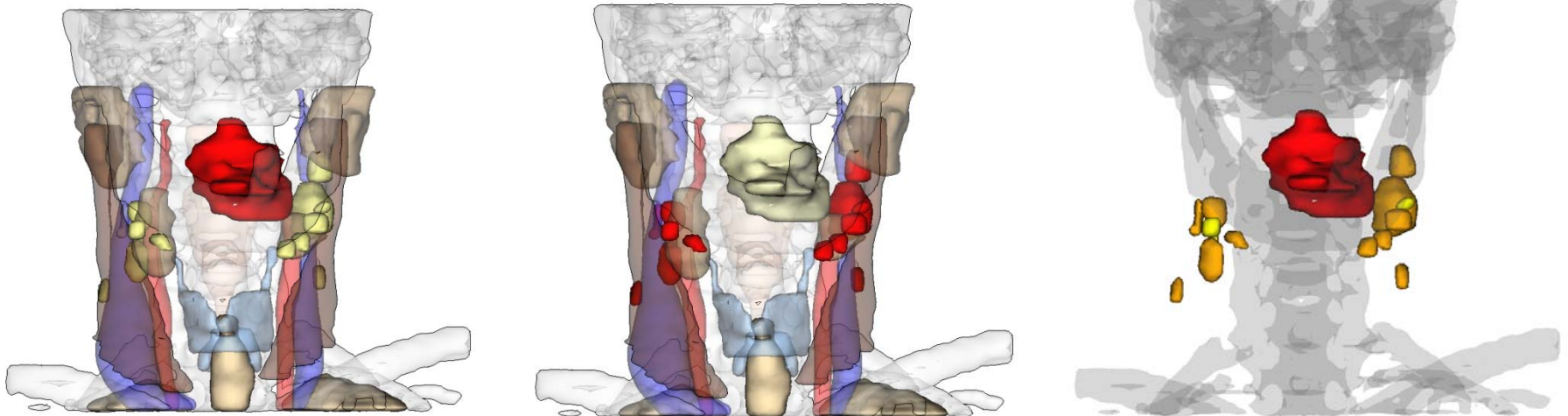
- Support medical experts exploring patient individual datasets and presenting diagnosis and treatment results
- Patient specific visualizations that efficiently illustrate:
 - Relevant structures
 - Pathological and functional relations between structures e.g. infiltration
 1. Treatment-guided selection of relevant structures
 2. Perception-based validated illustrative techniques

Therapeutic question:

How did the pathological structures spread ?

→ Focus structures are all pathological and suspicious structures

→ Focus-relevant are the bones



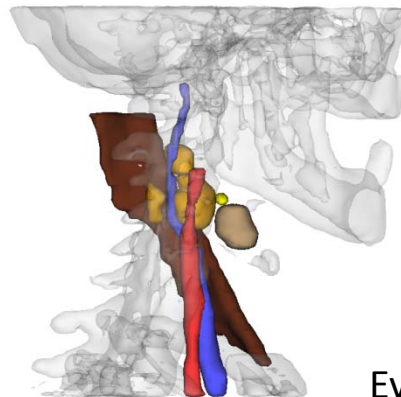
Neck visualization including tumor and enlarged lymph nodes.

Treatment-guided authoring system:

- Therapeutic question defines the focus and the relevant structures
- Customized visualizations for various therapeutic questions using one dataset with associated segmented structures
- Minimal user effort
 - Support of medical education, diagnosis and therapy planning systems
 - Facilitates generation of specific visualizations
(e.g. interdisciplinary tumor board discussions or presentations)

Framework:

- Segmented data with appropriate meta information is required
- Categorization of structures (pathological, suspicious, anatomical)
- Computation of structure relation matrix regarding
 - Meta data (name, structure type, side, etc.)
 - Geometrical properties (minimal distance, intersection volume, occlusion)
 - Pathological properties (critical distance, degree of severity)



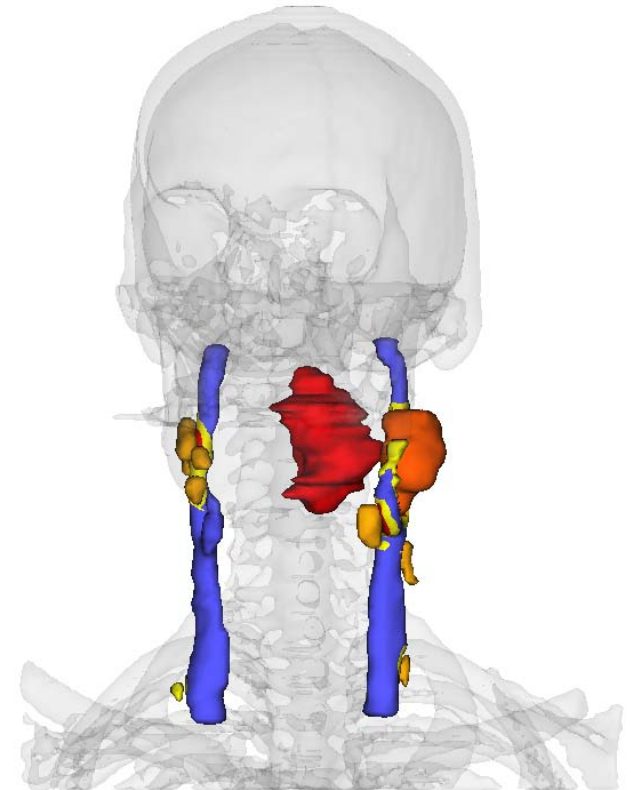
Evaluation of pathological

- Focus definition
 - Interactive specification
 - Derived from therapeutic question (e.g. spreading of pathological structures)
- Therapeutic question is represented as weights applied to the relation matrix
- Classification in focus-relevant and context structures using a threshold-technique
 - Automatic selection of important structures

Therapeutic question:

Are there potential infiltrations or intervention risk for the vena jugularis left and right?

- Focus : vena jugularis left and right
- Focus-relevant : pathological structures within critical distances to veins
- Context : all other essential anatomical structures

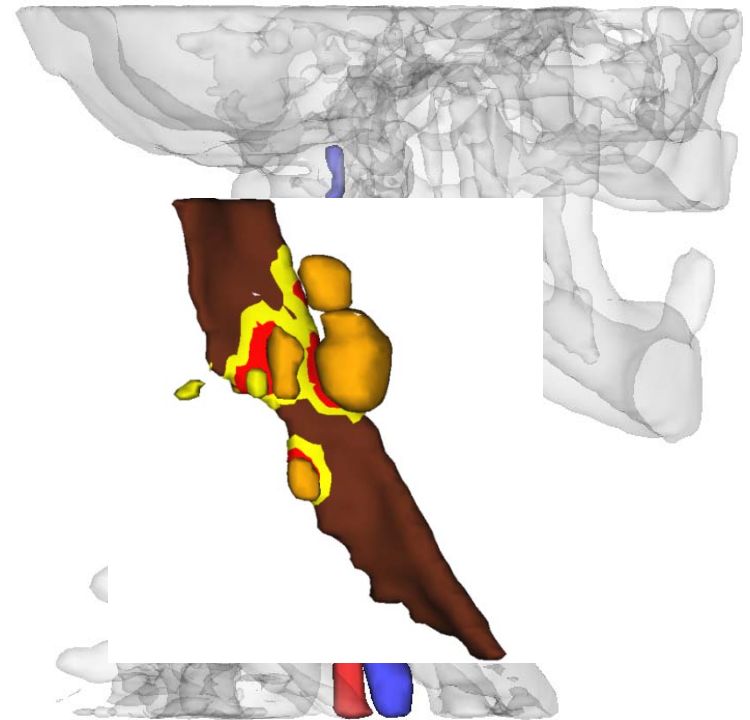


Vena jugularis left and right in correspondence to tumor and enlarged lymph nodes.

Therapeutic question:

Are there potential infiltrations or intervention risk caused by a specific pathological lymph node ?

- Focus : selected lymph node
- Focus-relevant : anatomical structures within critical distances to lymph node
- Context : all other essential anatomical structures



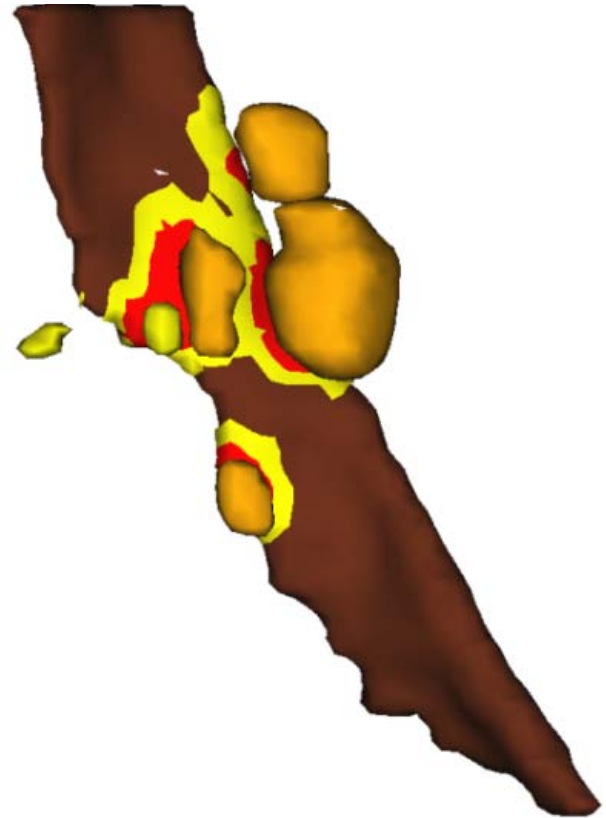
Examination of local risk area.

Achieved :

Selection of important structures

What next?

Which technique is suitable?



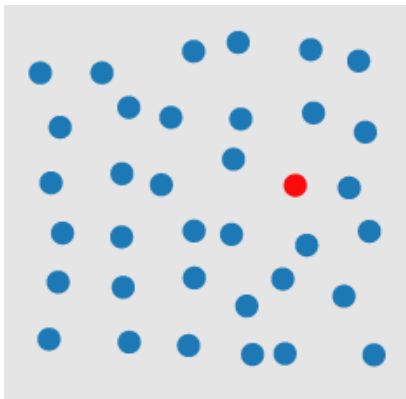
- Evaluation of illustrative techniques regarding focus detection
- Experimental setup for complex anatomical scenarios based on psychophysical user studies
- Can common psychological user studies be applied to our task?

Psychology:

- Human perception is examined by various user studies (reaction time tests, EEG, fMRT, MEG, etc.)
- Expressive visual search task experiments
 - Determine whether target is present or absent in a field of distractors

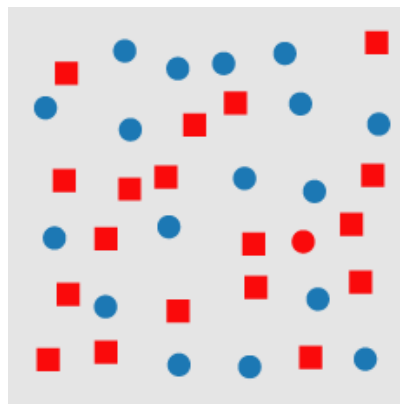
Feature search:

target strongly differs
in one feature



Conjunctive search:

combination necessary to detect
target

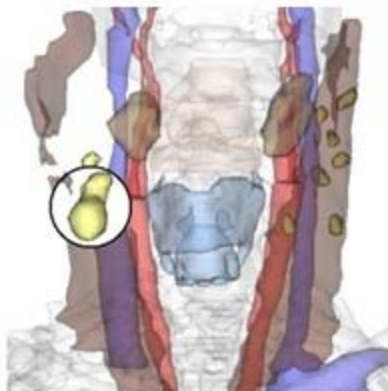


Requirements:

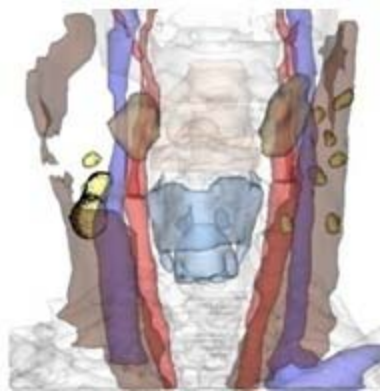
- Research hypotheses have to be properly postulated in advance
- Reliable software for execution and data recording
- Identical conditions for each subject
 - Instruction
 - Environment
 - Execution

Experimental setup for our study:

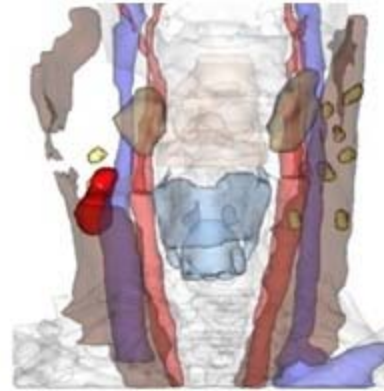
- Visual search task experiment with clinical neck visualizations
- Task: Detection of enlarged lymph node
- Emphasis techniques : cutaway, stippling, red coloring



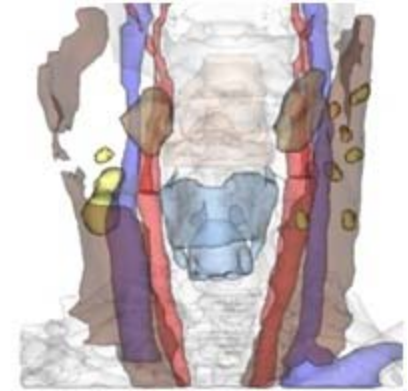
Cutaway



Stippling



Red



No Emphasis

Hypotheses:

- H1 : Emphasized enlarged lymph nodes are detected more often and faster than those without emphasis.
- H2: Cutaway will be more efficient regarding accuracy and reaction time than stippling and red coloring.

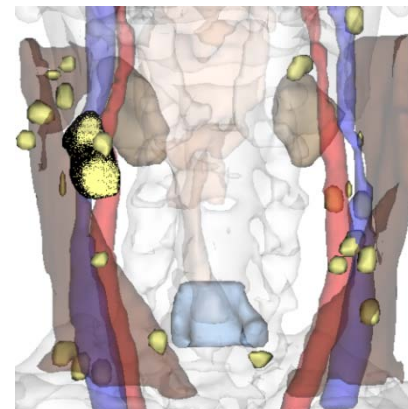
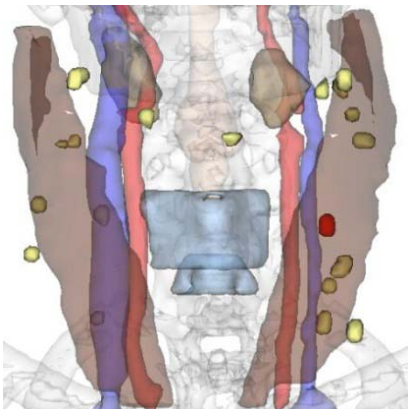
Measured Parameters:

- Reaction time and accuracy (hit rate)
- False Alarm rate to validate the subjects' reaction tendency (signal detection theory)

		Perception	
		Detected	Not detected
Stimuli	Target	Hit	Miss
	Noise	False Alarm	Correct Rejection

Stimuli:

- Neck visualization including vessels, muscles, bones, pharynx, glands and several lymph nodes are presented
 - Same structures in each image
 - Viewport is defined by muscle extension
- Noise
 - No enlarged lymph node
 - One lymph node may be emphasized or not
- Target:
 - Contains one enlarged lymph node (≥ 30 pixel)
 - Enlarged lymph node may be emphasized or not



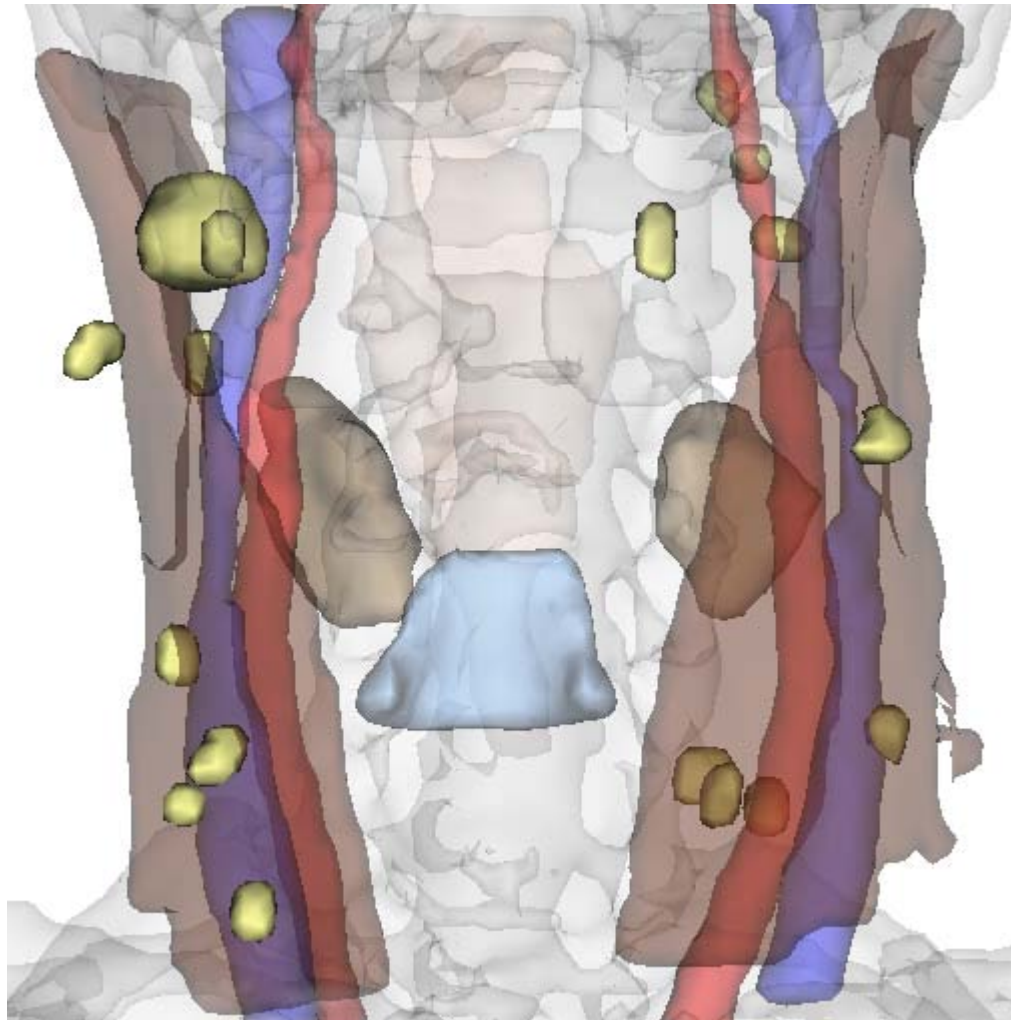
Experiment Conduction:

- Stimuli presentation for 1.1 s
 - Size of image 512 x 512 pixel
 - 1163 images arranged in 8 trials
 - Target and noise images random but equally often presented
 - Emphasis techniques randomly displayed
- A fixation cross followed each stimulus (displayed for 750 – 1250 ms)

Stimuli	Images per Subject
Noise	~586
Target	~577
No technique	~137
Red	~146
Stippling	~147
Cutaway	~146

Experiment Conduction:

- For each presented stimulus the subjects had to:
 1. press left mouse button if enlarged lymph node is present
 2. press right mouse button if no enlarged lymph node is found
 - Subjective opinion recorded after finishing (question paper)
- Experiment duration: 1 hour



Statistical Analysis:

- Measured data
 - Reaction time in ms for hits
 - Hit rate and false alarm rate in %
- Apply significance test to the means of reaction time and hit rate for target images (hits)

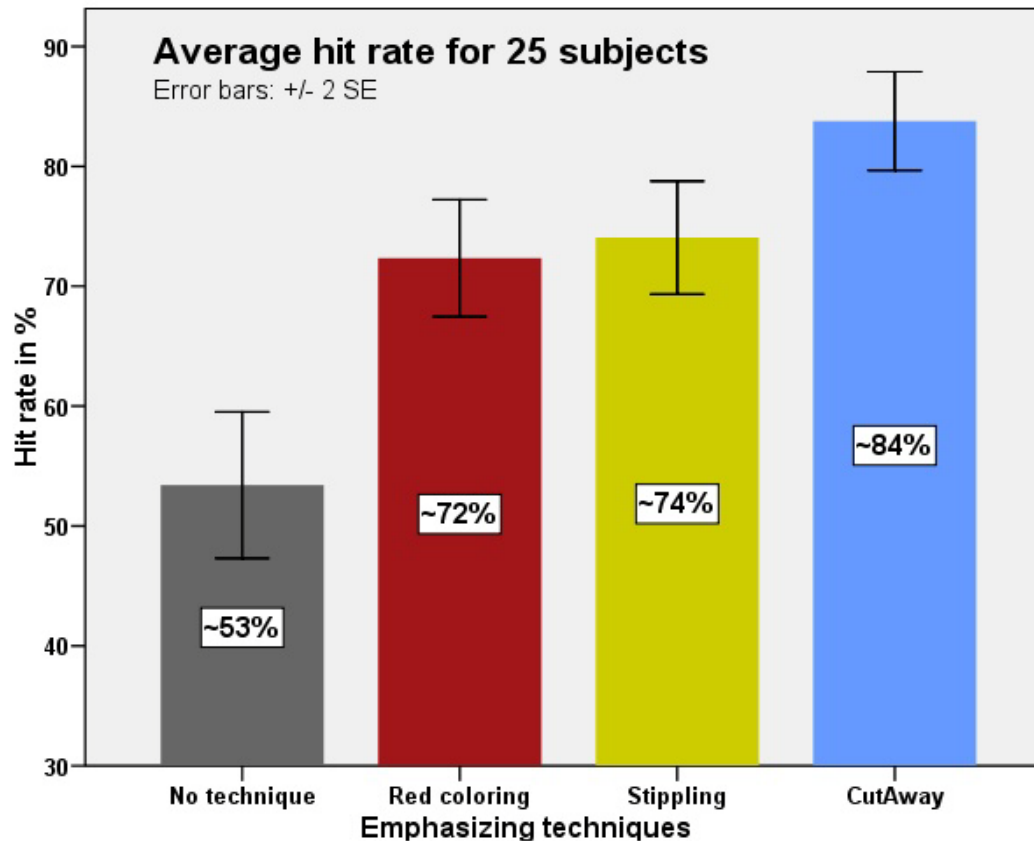
	Hit Rate	Reaction Time
Normal Distribution	Shapiro-Wilk X	Shapiro-Wilk ✓
Significance Test	Friedmann $p \leq 0.001$	ANOVA $p \leq 0.001$
Paired Test	Wilcoxon	T-Test

→ Significant difference existent

→ No significant difference for stippling compared to red coloring

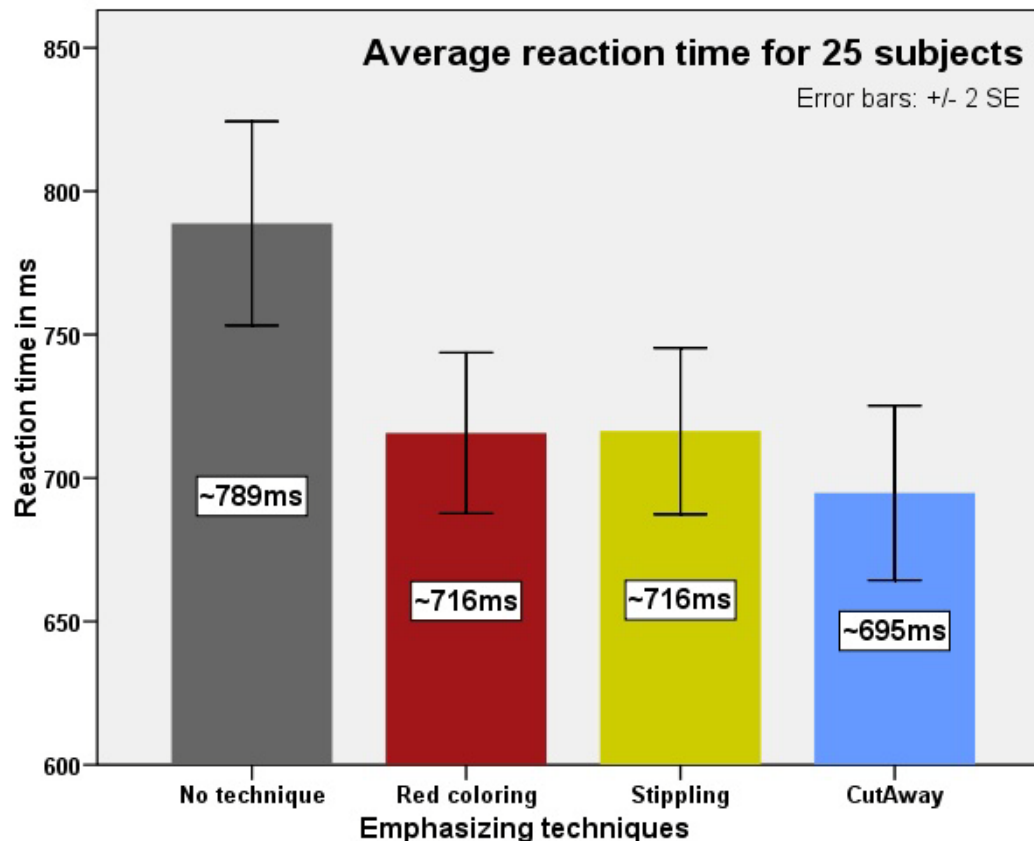
Perception-based User Study

- H1 : Emphasized enlarged lymph nodes are detected **more often** and faster than those without emphasis.
- H2: Cutaway will be more efficient regarding **accuracy** and reaction time than stippling and red coloring.



Perception-based User Study

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Results:

- Confirmation of hypotheses
- 30 subjects participated
 - Medical experts, psychology students, engineering students, designer, others
 - 5 subjects were neglected because of hit rate below 50 %
 - 24 of 25 achieved with cutaway the best hit rate, 1 with stippling
 - 15 of 25 subjects received with cutaway the fastest results
- False alarm rate below 8 %
- In 8 of 25 cases the subjective opinion did not match with received hit rate

- Expressive medical visualizations achieved by analyzing respective therapeutic purposes and using suitable illustrative techniques
- Perception-based user studies validate illustrative techniques in medical visualizations used for specific tasks
 - Restriction to a few investigating factors (e.g. limited number of techniques)
 - Focus on one therapeutic aim or at least on one anatomical domain
- Treatment-guided and perception-based visualizations facilitate and accelerate the exploration process

- Evaluation of further techniques and medical scenarios
- Studies with customized visualizations
 - Technique classification corresponding to focus, focus-relevant and context structures
- Perception-guided exploration in medical illustrations according to visual perception (Guided search theory)
 1. Detection and localization of relevant structures
 2. Detailed exploration of focus structures

Thank you !

Questions?