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SURGICAL INSTRUMENT SIMILARITY METRICS AND TRAY ANALYSIS FOR MULTI-SENSOR INSTRUMENT IDENTIFICATION

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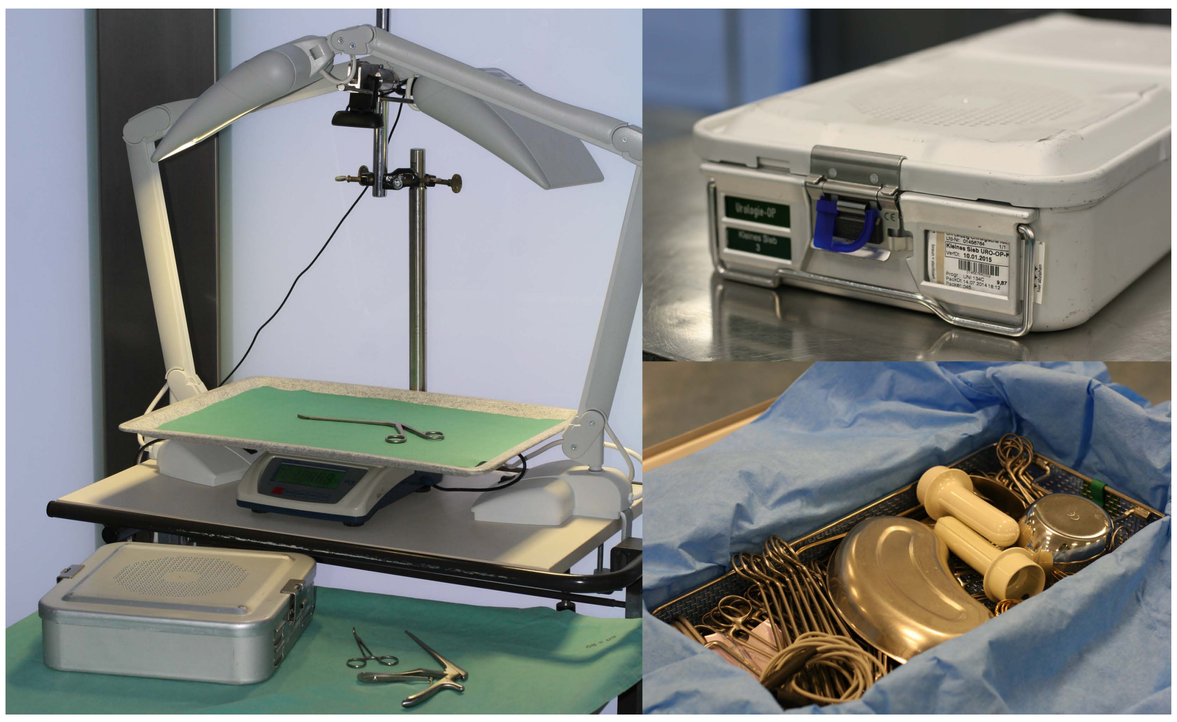
INTRODUCTION

A robust identification of the instrument currently used by the surgeon is crucial for the automatic modeling and analysis of surgical procedures. We presented a novel system design of a surgical instrument detection system without the need for modification of the instruments, which works with the scrub nurse's instrument table and differs completely from all existing approaches. Reasonable results were obtained in a preceding study [1], however only one type of surgical intervention and the related surgical tray were analyzed. To generalize the approach and to investigate further the portability and adaptability of a video- and weight-based approach, the goal of the presented work is to analyze multiple trays from four different surgical domains for similarities of weight and shape and to introduce a new metric for the suitability of a surgical tray for video and weight based detection approaches.



METHODS

A metric was developed to introduce a measurable quantity for the applicability of video and weight based detection of the instruments of a surgical tray. Let T be the set of all instruments in a surgical tray. Let $\tilde{T}$ be the set of all unique instruments in this tray, where each instrument with multiple occurrences in T is represented by one randomly chosen exemplar. For the detection algorithm, the set of all candidates C_t^{video} for an instrument t with a similarity s_t^{video} above a threshold ε is defined as

$$C_t^{video} = \left\{ t' \in \tilde{T} \mid s_t^{video}(t') \geq \varepsilon \right\}$$

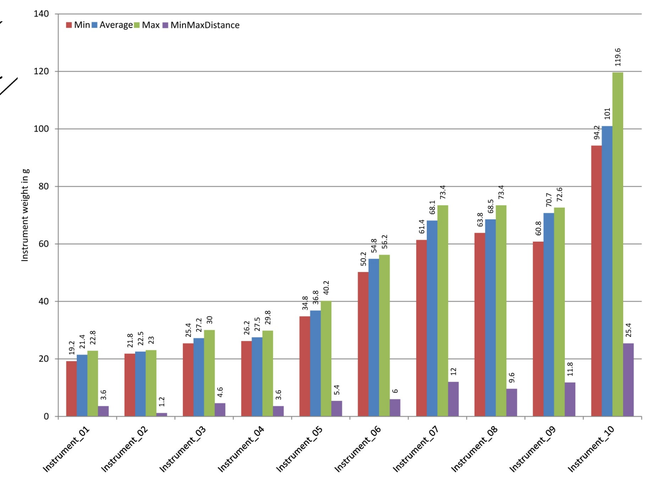
The metric $\omega^{video}(\tilde{T})$ with

$$\omega^{video}(\tilde{T}) = \frac{\sum_{t \in \tilde{T}} \left| C_t^{video} \right|}{\left| \tilde{T} \right|}$$

defines a measure for the average number of candidates that are considered when identifying an instrument of tray T. By nature a value $\omega^{video}(\tilde{T}) = 1$ is optimal for a tray. $C_t^{video\&weight}$ and $\omega^{video\&weight}(\tilde{T})$ are defined analogously.

RESULTS

trayname	# instruments	# unique instruments	ω video	ω video&weight	percent improvement
abdom1	101	53	2	1.5	25.0%
abdom2	91	64	2.2	1.5	31.8%
abdom3	72	50	2.2	1.4	36.4%
neuro1	106	65	2	1.3	35.0%
neuro2	90	69	1.9	1.4	26.3%
neuro3	36	31	1.3	1.1	15.4%
ortho1	101	65	1.8	1.2	33.3%
ortho2	41	33	1.5	1.1	26.7%
ortho3	138	100	4.2	2.1	50.0%
urology1	83	51	1.7	1.4	17.6%
urology2	23	16	1.1	1	9.1%
urology3	76	50	1.9	1.4	26.3%
abdom	264	131	3.4	1.9	44.1%
neuro	232	122	2.4	1.4	41.7%
ortho	280	183	4.1	2	51.2%
urology	182	91	2.1	1.5	28.6%
all	958	457	6.3	2.6	58.7%



The left table shows the results for the trays of each surgical domain and also the results for combination of these trays (*abdom, neuro, ortho, urology*) as well as the results for the combination of all instruments used in the study (*all*). The right figure illustrates the results for a weight analysis of ten randomly chosen surgical instruments with ten analyzed exemplars for each instrument. The samples for the single instruments indicate high weight variability in instruments with identical brand and model.

DISCUSSION & CONCLUSION

The addition of weight information for better accuracy in the detection of visually similar surgical instruments shows promising improvement percentages, especially with large amounts of instruments in combined trays. The high weight variability in the analyzed samples of single instruments with identical brand and model number shows, that a successful usage of weight information requires either high weight tolerance in the the applied detection algorithm or references to the explicit exemplar of the instrument in the reference container.

[1] Glaser, B., Dänzer, S., Neumuth, T.: Intra-operative surgical instrument usage detection on a multi-sensor table. Int. J. Comput. Assist. Radiol. Surg. *In print* (2014).

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