Software-based automated measurement of susceptibility artifacts on magnetic resonance images

Andreas Heinrich[1], and Felix Guettler[1]
[1]*Department of Radiology, University Hospital Jena, Jena, Thuringia, Germany*

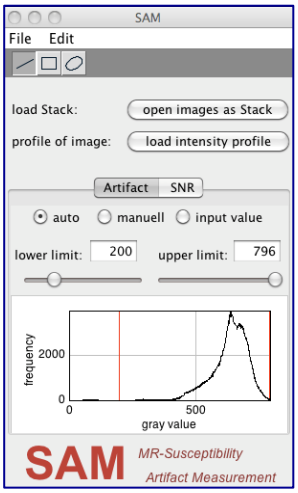


Figure 1: *Graphic surface of SAM. First, a DICOM-serie is loaded pushing the button "open images as Stack". The artifact measurement can get started with button, "load intensity profile". A reference value can be defined automatically (auto), manually in a reference measurement (manual), or through a direct input (input value).*

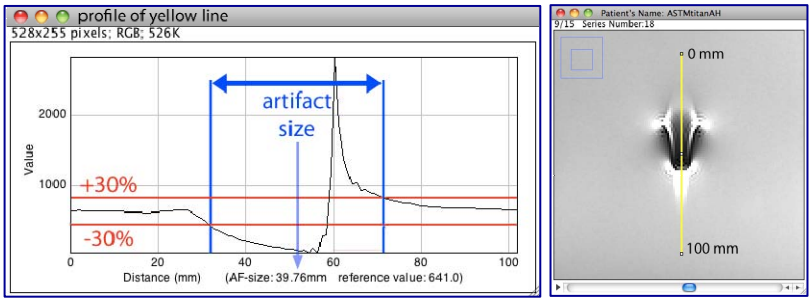
Introduction:

MR-compatible implants and instruments for interventions under MR-imaging can cause susceptibility artifacts [1, 2]. Before clinical diagnostics or intervention, it must be known in what extent those artifacts could overlay the tissue of interest. For that reason, ASTM developed the standard F2119 [2] which describes how to determine the artifact' size of passive implants. The standard defines precisely a susceptibility artifact, but gives only a vague method for artifact measurement. This had led to different methods to determine the greatest artifact, such as the categorization [3] and the assessment with measurement tools [4]. The objective was to develop a platform-independent software system for rapid, objective and reproducible measurement of susceptibility artifacts that complying with ASTM.

Material and Methods:

An ImageJ (Java) based software SAM (http://sam-toolbox.sf.net) was created, which automatically calculates the greatest susceptibility artifact according to ASTM F2119-07. The required reference value is defined either by a reference image without artifact-generating test object or automatically with test object from the histogram of the stacks (see figure 1). To evaluate the software according to ASTM, the artifact of a titanium cylinder (diameter: 10mm, height:10mm) was measured with a Siemens Magnetom Avanto. 13 probands located the greatest artifact in horizontal and vertical alignment in respectively 12 data records (see figure 2). Thereby, three different tools were used: a) a measurement tool of the software Osirix, b) SAM with a reference value of the histogram, and c) a reference measurement (only 5 probands).

Figure 2: *The intensity profile is represented through the yellow line in the DICOM image (on the right). The artifact starts as soon as the grey value of a pixel differs more than 30% of the reference value. The greatest extent can be defined scanning the artifact with the yellow line.*



Results:

The average values between method a and b showed a difference of (3,3 ± 3,2) mm, between a and c (3,9 ± 3,5) mm and between b and c (1,0 ± 1,4) mm (see figure 3). The standard deviation amounted for method a 8,1 mm, for b 1,3 mm and for c 1,8 mm. With the SAM software, the dispersion of the results could be reduced to over 80%. With method a, the probands had to estimate and measure the artifact independently. The software SAM defines the greatest artifact automatically through scanning. In method b, all probands used the same reference value automatically, whereas it had to be fixed manually in method c and varied in the middle by a value of 15.

Conclusions:

A rapid, objective and reproducible measurement of susceptibility artifacts is possible with the developed software SAM. Furthermore, the software safes 50 % of MR measurement time, since the required ASTM reference images without test object are not necessary.

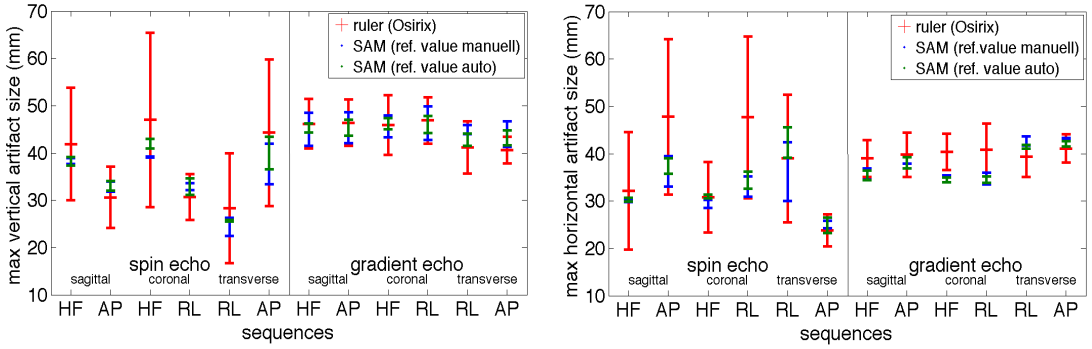


Figure 3: *Measurement of the vertical (left) and horizontal (right) artifacts' size of a titanium cylinder with Osirix and SAM. The reference value for the SAM software was determined with two methods (auto: automatically from the histogram with test object, manual: from a reference measurement without test object). Three cutting directions with each two frequency encoded directions were analyzed.*

References:

[1] *Wonneberger, U., B. Schnackenburg, et al. (2010). "Evaluation of magnetic resonance imaging-compatible needles and interactive sequences for musculoskeletal interventions using an open high-field magnetic resonance imaging scanner." Cardiovascular and interventional radiology 33(2): 346-351.*
[2] *ASTM Standard F2119–07 (2007). "Standard test method for evaluation of MR image artifacts from passive implants." ASTM International, West Conshohocken, PA, 2001, DOI: 10.1520/F2119-01, www.astm.org.*
[3] *Edwards, M. B., K. M. Taylor, et al. (2000). "Prosthetic heart valves: evaluation of magnetic field interactions, heating, and artifacts at 1.5 T." Journal of Magnetic Resonance Imaging 12(2): 363-369.*
[4] Chen, C., et al. (2010). "SEMAC and MAVRIC for artifact-corrected MR imaging around metal in the knee." Proceedings of the ISMRM, Stockholm, Sweden: 130.