Further Customization of Dot Engines: AutoCoverage

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Introduction

In 2009 Dot engines introduced a very powerful customization tool: AutoCoverage. AutoCoverage ensures the anatomy under examination is covered consistently throughout the entire examination. Moreover, the adjustments to the coverage will be done in a standardized way independent of the choices and/or skills of the operator.

Tailoring the coverage of the patient’s anatomy can be done via the AutoCoverage parameter card. This card can be found in many of the Dot AddIns. The availability of Dot AddIns depends on the Dot engines purchased. This article uses the Generic Views Dot AddIn that is included in the Brain Dot Engine and is part of the standard system configuration for virtually all our MR systems on the D and E software levels.

Most of the available Dot engines, including the Brain Dot Engine, contain an AutoAlign (AA) Scout: e.g. AAHead_Scout, AASpine_Scout, AAHip_Scout and so on. These AutoAlign Scouts provide the landmarks and the orientation for positioning the slices in a standardized way independent of the operator.

However, these AutoAlign scouts provide more information about the anatomy by means of an organ box. This organ box is a cuboid which defines the boundaries of the anatomy under examination, and which can be adjusted in size by the user. This information not only enables us to position the slices in a standardized way, but also to ensure that the coverage of the anatomy is tailored to the individual patient’s anatomy. The adjustments can be done within these Dot AddIns, and ensure that the coverage is always adjusted in the same way throughout the whole examination, whether by changing the number of slices, slice thickness or distance factor (or a combination of these).

Organ boxes

An organ box defines the boundaries of the anatomy under examination. There are several organ boxes available with the AutoAlign Scouts which are delivered with the Dot engines. This article will focus on the organ box ‘Brain’ that is available with the Brain Dot Engine, but the principles and adjustments described can be applied to any of the other organ boxes that are available on the system.

One should note that there is a distinct difference between an AutoAlign Reference and an organ box. The AutoAlign Reference defines just the orientation and position based on landmarks as detected by the AAHead_Scout. However, the organ box will provide additional information for the AutoAlign Reference in terms of the boundaries of the anatomy. This information can then be used to adapt the coverage of the anatomy which is enclosed by the organ box to ensure the coverage is done correctly, independent of the size of the individual patient’s anatomy.

Adaptation to the coverage can be made via the edges of the cuboid of the organ box in any of the three orthogonal axes: phase, read and slice selection.

The edges of the cuboid that represents the Brain organ box as shown in Figure 1 are labeled A, B and C. These dimensions can be used for AutoCoverage to adjust the field-of-view (FOV) and coverage in the slice direction in a standardized way. For example, for the transversal plane A and B could be used to adapt the FOV, whereas C can control the ‘coverage’ in the slice direction. For the sagittal plane, B and C could be used by the FOV and A can control the ‘coverage’ in the slice direction and so on. How one can actually use this organ box to adjust the FOV and/or coverage in the AddIn will be described in the next section: AutoCoverage in the Brain Dot Engine.
AutoCoverage in the Brain Dot Engine

In order to utilize the AutoCoverage functionality we need to make sure that we measured an AAHead_Scout first. Remember, the AAHead_Scout will provide both the AutoAlign references and set the boundaries of the ‘organ box’. Additionally, we need to ensure that every protocol that we want to make use of AutoCoverage is actually configured with a Dot AddIn that has that AutoCoverage functionality enabled. For demonstration purposes, the remainder of this article uses the Generic Views AddIn to explain the AutoCoverage functionality.

The Brain Dot Engine comes with two organ boxes: Brain and Temporal Lobe. The dimensions of the Brain organ box are shown in Figure 2. As can be seen, the ‘Brain’ organ box uses the AutoAlign reference ‘Brain’ for the correct orientation and position of the transversal brain images.

We next look at how the organ box can be used in the Brain Dot Engine.

Firstly, ensure that a Generic Views AddIn is associated with the protocol: drag and drop a Generic Views from the Default AddIns directory, or any other Dot AddIn that has this AutoCoverage functionality, on the protocol you want to work on as shown in Figure 3.

Secondly, open the AddIn Configuration. This can be done by clicking on the ‘Add-In’ configuration button found on the left bottom of the window of the protocol (Fig. 4) provided the protocol has an AddIn associated with it.

![Dimensions of the Brain organ box.](image1)

![Drag and Drop Generic Views AddIn.](image2)

![Button AddIn Configuration.](image3)
The AutoCoverage parameter card is shown on the left side of the Dot AddIn Configurator window (Fig. 5). AutoCoverage is available in most Dot AddIns, for example the Generic Views or MPR Assignment (in this case the Generic View AddIn is used).

Thirdly, enable AutoCoverage on the Dot AddIn Configurator window (Fig. 6).

Fourthly, choose the organ box to be used for AutoCoverage. Within the Brain Dot Engine there are two organ boxes to choose from. For further illustration the organ box ‘Brain’ is chosen from the drop down menu as shown in Figure 7.

As mentioned above, the AAHead_Scout run at the beginning of the Dot Engine, not only sets the AutoAlign references, but also the dimensions of the organ boxes (Brain and Temporal Lobe in case of the AAHead_Scout). If you want to adjust the size of the organ box as set by the AAHead_Scout, select the button with the three dots (behind the chosen organ box). Another window (Fig. 8) will pop-up and the desired adjustments to the size of the organ box can be made to all three (read, phase and slice) encoding directions. The size can be increased or decreased (enter a negative value). Please note that the adjustments to the organ box (edges of the cuboid shown in Figure 2) are specific to the orientation of the slices and therefore are different for other orientations.

Fifthly, the option ‘Propagate changes to all following protocols’ (Fig. 9) ensures that any changes you made during the positioning of this protocol – which in effect changes the FOV and/or coverage – will be applied to the subsequent protocols.

In a typical brain examination this is actually a less often used feature. The FOV used in Brain examinations is usually fixed and not set to a minimum as defined by the dimensions of the individual patient’s anatomy. However, in abdominal examinations this is certainly more frequently done and it is quite a nice feature to tailor the protocol to the patient’s anatomy. Please note that you require the

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**How-I-do-it**

1. Enable AutoCoverage.
2. Choose Organ box.
3. Change size of the Organ box.
4. Propagate changes to all following protocols.
Abdomen Dot Engine to make use of the AutoCoverage feature in abdominal examinations.

**Warning:** Changing the FOV in one direction might also influence the coverage of the slices in another direction when ‘Propagate changes to all following protocols’ is used. Figure 10 demonstrates what happens when we use ‘Propagate changes to all following protocols’. One should be aware that while the prescription (using AutoCoverage) is the same for the transversal protocol in the user interface, the effect of the settings of ‘Propagate changes to all following protocols’ makes a big difference for the sagittal protocol following this transversal protocol. In Figure 10A the setting for ‘Propagate changes to all following protocols’ was unchecked. This will result in a proper coverage of the brain from right to left. In Figure 10B the setting for ‘Propagate changes to all following protocols’ was checked and results in coverage as large as the rectangular FOV (phase direction) set in the transversal protocol.

The reason for this is that when ‘Propagate changes to all following protocols’ is used, the FOV of the transversal protocol changes the size of the organ box in the read and phase direction (indicated by the dotted green box in Figure 10). Consequently, the organ box is changed in the slice direction for the sagittal protocol and AutoCoverage will now ensure that this complete organ box in the slice direction is covered.

As can be seen in situation A, where ‘Propagate changes to all following protocols’ is off, the organ box is still the size of the brain in both the read and phase direction. But in situation B, where it is ‘on’, the size of the organ has been adjusted to the FOV in both read and phase direction. While the size in the read direction does not have a direct influence on this sagittal protocol, the change in phase direction results in a larger coverage than necessary. Only in cases when the subsequent orientations are the same, the option ‘Propagate changes to all following protocols’ might be useful, but must be used carefully.

Sixthly, the next parameter ‘Keep FOV constant’ (Fig. 11) ensures that the FOV defined in the underlying protocol is not changed by the AutoCoverage settings. This option can be used in protocols where the FOV is not changed according to the size of the patient’s anatomy. ‘Keep FOV constant’ in effect disables the AutoCoverage feature in the phase and read direction, while it still works in the slice orientation.

![Results of ‘Propagate changes to all following protocols’](image_url)
Seventhly, the next configuration step in the AutoCoverage card is the actual ‘brain’ of AutoCoverage. In order to adjust the coverage of the anatomical region in a standardized way, one needs to configure so-called manipulations to make modifications to the underlying protocol to ensure the complete anatomy is covered.

The default Generic Views Dot AddIn, as used for the transversal protocols in the Brain Dot Engine (this example is from a MAGNETOM Skyra running on software version syngo MR E11A), typically has three steps to achieve sufficient coverage (Fig. 12):

1. Increase the number of slices up to a maximum of 30 in increments of 1 slice at a time until sufficient coverage is achieved, if not proceed to the next step,
2. Increase the slice thickness up to a maximum of 4.5 mm in increments of 0.1 mm at a time until sufficient coverage is achieved, if not proceed to the next step,
3. Increase the distance factor up to a maximum of 40% in increments of 5% at a time until enough coverage is achieved.

If these three steps are not enough to cover the entire organ box, the user will get a warning (‘The FOV was adapted to the limit of AutoCoverage. Please Check!’) on the Guidance View card of the open protocol in the Queue (Fig. 13). The warning indicates that the AutoCoverage was not successful and needs to be checked by the user.

Additionally, an AutoAlign icon with the yellow warning triangle will be shown in the queue (Fig. 14). But where AutoCoverage was successful the user can also see which changes have been made to the original protocol. This information is visible when the mouse is hovered over the information button (italic i in blue circle) located at the bottom of the Generic Views Guidance card (Fig. 15).

By default the manipulations in the AutoCoverage are set up such that an adjustment will be made only where the coverage of the organ box was insufficient; it will only increase the number of slices, slice thickness and/or distance factor. Where the anatomy in the slice direction is actually smaller than the organ box detected, no changes will be made. If the size of the organ box is by coincidence the same as the coverage defined by the protocol (number of slices, slice thickness and distance factor), the system will also indicate there are no changes necessary. From the information provided by the information button, the user would not be able to tell if either exact coverage or smaller anatomy produced the message ‘AutoCoverage was successful without changing the protocol’.

To have AutoCoverage also adjust the coverage in situations where the size of the actual anatomy, as defined by organ box, is smaller than defined by the underlying protocol (number of slices, slice thickness and distance factor), a simple adjustment to the manipulations is all that is required. The user need only insert an extra manipulation at the top by clicking on the ‘+’ sign in the manipulations setup box (Fig. 16). This extra manipulation must be moved with the arrow key to the top and is actually the first manipulation. The manipulation should then be changed such that the Slices ‘=’ 1 as shown in Figure 16. This will effectively set the number of slices first to 1. When multiple concatenations
To ensure enough coverage are different for 2D and 3D protocols. To make sure that manual adjustments to the proposed coverage by the user, like increasing the number of slices, is done for all protocols in the same orientation (and require the same coverage), it is recommended to work with Copy References (‘Slices’ / ‘Slices and saturation regions’ / ‘Slices and Adjust Volume’) in order to keep the changes in coverage the same for all linked protocols. This is necessary since we switched off ‘Propagate changes to all following protocols’ and therefore the manual adjustment to the coverage by the user, are not propagated to the following protocols. The system will give priority to Copy References over AutoCoverage. Please note that in this case the coverage for the 2D cannot be propagated to 3D protocols by Copy References and would require a manual interaction by the user.

The last option on the AutoCoverage parameter card is very useful when using AutoCoverage. Increasing the coverage from the underlying protocol might result in a higher chance of SAR pop-ups. The number of SAR pop-ups can be reduced using the SAR Assistant, either by increasing the TR to a certain maximum, or by reducing the flip angle to a certain minimum to be able to scan the protocol within the current SAR limits without interaction of the user. Depending on the underlying protocol, either option can be chosen and configured as shown in Figure 18.

Conclusion
This article details the steps to adjust and manipulate the coverage in the slice direction by using the AutoCoverage functionality available in many Dot AddIns by the use of the organ box as provided by the AAHead_Scout. In practice when there are other AutoAlign Scouts available on the system, the modifications to the coverage can be made by using any of the organ boxes available with these AutoAlign scouts. The AutoCoverage parameter card is a very powerful option, and will ensure that the complete anatomy, as detected by the organ box, will be covered in the underlying protocol. At the same time, steps to ensure that the coverage is achieved, will be executed in a standardized way and adjustments are independent of the choices and/or skills of the operator. However, it will remain the responsibility of the user of the MR system to confirm the correct coverage of the anatomy of interest.

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