ACTIVE OPTICAL SYSTEMS

AN067

Handling Poorly Illuminated Actuators in Adaptive Optics

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1 Introduction

It is common that a DM with many actuators is used in only the central region due to limitations of the optical system. This application note addresses this problem with four possible solutions including removing SVD modes, disabling actuators, grouping actuators, and slaving actuators.

2 Approach

There are four approaches that can be used with differing degrees of efficacy based on the specific details of the system. There is an accompanying presentation to this application note that can augment this note. The kind of configuration we are considering here is illustrated in Figure 1. The central region is well sampled by a wavefront sensor. The edges are not illuminated sufficiently to be effective over the beam area.

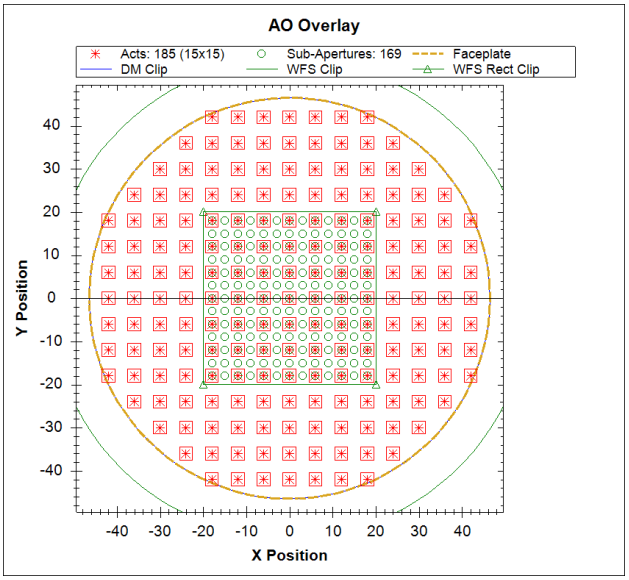

Figure 1: AO Overlay with Poorly Illuminated Actuators

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2.1 SVD Mode Removal

The easiest way to deal with poorly illuminated actuators in most systems is to remove SVD modes but there are several challenges with this approach. First, there is no guarantee that the removed SVD modes do not have content in the region spanned by the well-illuminated actuators. Removing the modes may cause the system to build up some residual error on the mirror surface. This can sometimes be alleviated with a lower leak scale factor (e.g. changing from 1.0 to 0.9). This sometimes means removing many SVD modes.

2.2 Disabling Actuators

In the AOS software, a user can disable actuators. A disabled actuator can be biassed to a middle range but will not change during adaptive optics. This can be useful if the useful edge actuators are not going to be constrained by the disabled actuators sitting at the bias. We have generally found that this is only useful for very small amplitude aberrations and can cause inter-actuator stroke limitations for aberrations that have larger amplitudes. This is easy to do in the AOS software but is not advised as a general solution to adaptive optics.

2.3 Grouping Actuators

In the AOS software, a user can group actuators together so that they all fire as one unit. Figure 2 shows an example of grouping actuators around a central rectangularly oriented illuminated area. The AOS software then fires these actuators as a unit during poke matrix and adaptive optics operation. This grouping is a manual process that can often be tedious and automated through the slaving process in the AOS Control Matrix Generation (CMG) software.

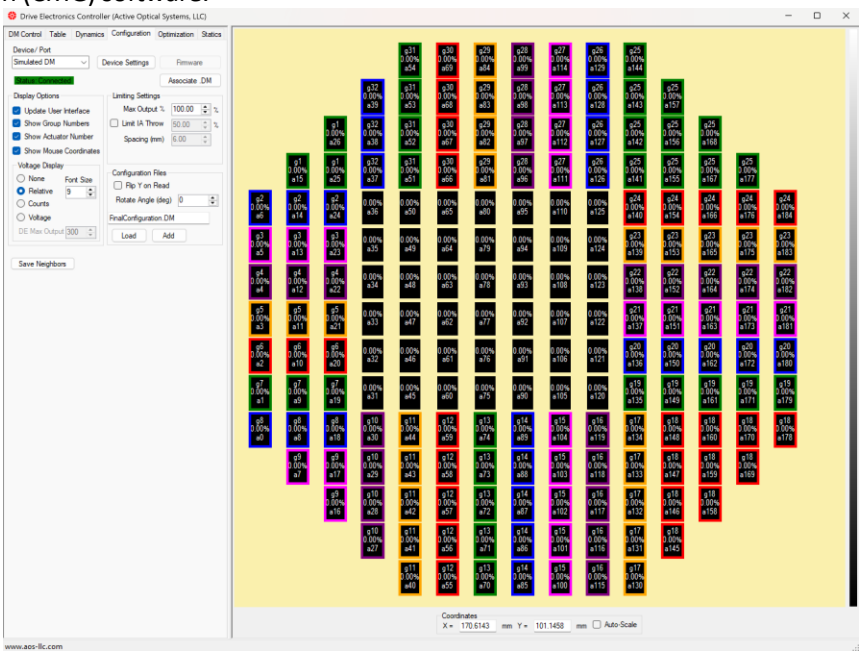

Figure 2: Example of Edge Actuator Grouping

Figure 3 shows how a poke matrix looks with and without grouping. Without grouping, there are many actuators that have nearly no response in the poke matrix resulting in large nearly blank areas. After grouping, the measured poke matrix nearly eliminated these areas.

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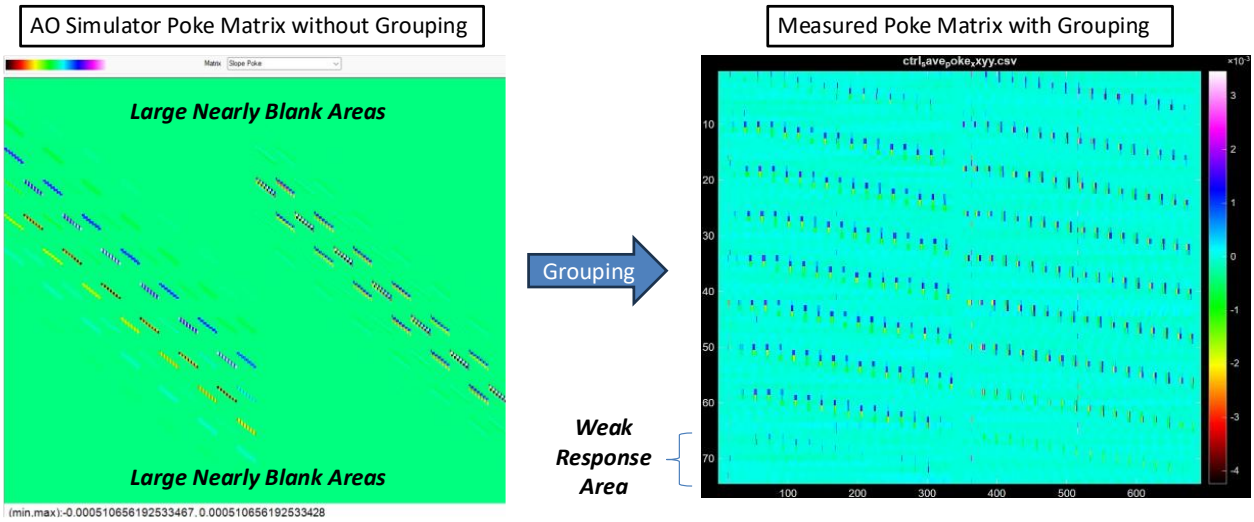

Figure 3: Evolution of a Poke Matrix with Grouping

2.4 Actuator Slaving

Figure 4 shows a sparse poke matrix loaded into the AOS Control Matrix Generation (CMG) software. We again see larger blank areas on the top and bottom of the poke matrix shown at the right of the screenshot.

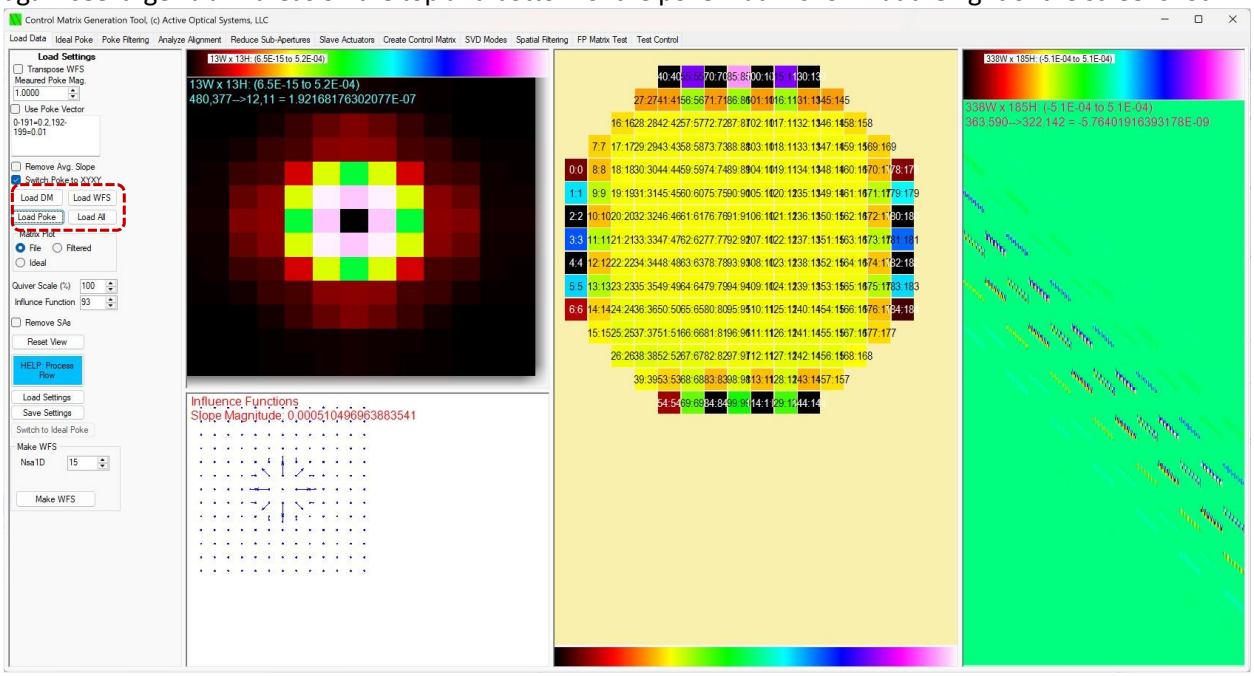

Figure 4: Sparse Poke Matrix Loaded into the AOS CGM Software

Figure 5 shows the "Slave Actuators" tab on the AOS Control Matrix Generation software. After pushing the "Slave Actuators" button, the software analyzes the amplitude of the response of each actuator in the poke matrix and then uses a user-defined threshold to separate master and slave actuators.

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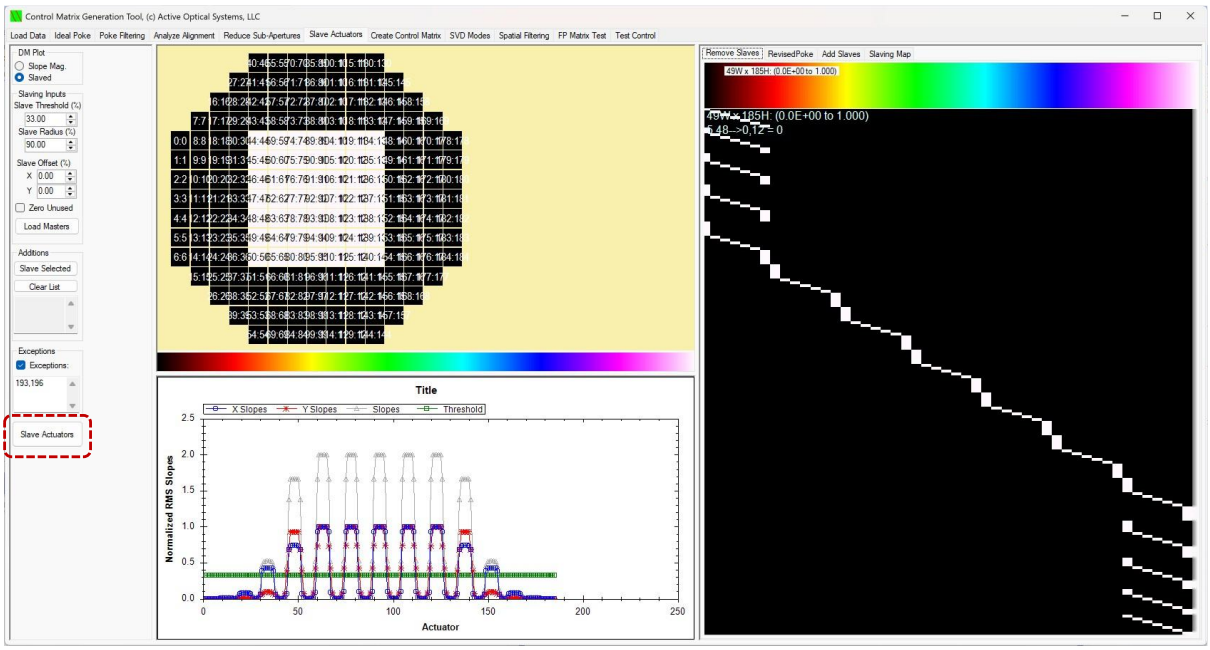

Figure 5: Slave Actuator Tab of the Poorly Illuminated Actuator Example

Slave actuators are then slaved to the nearest master. Figure 6 shows the slaving map from the AOS CMG software.

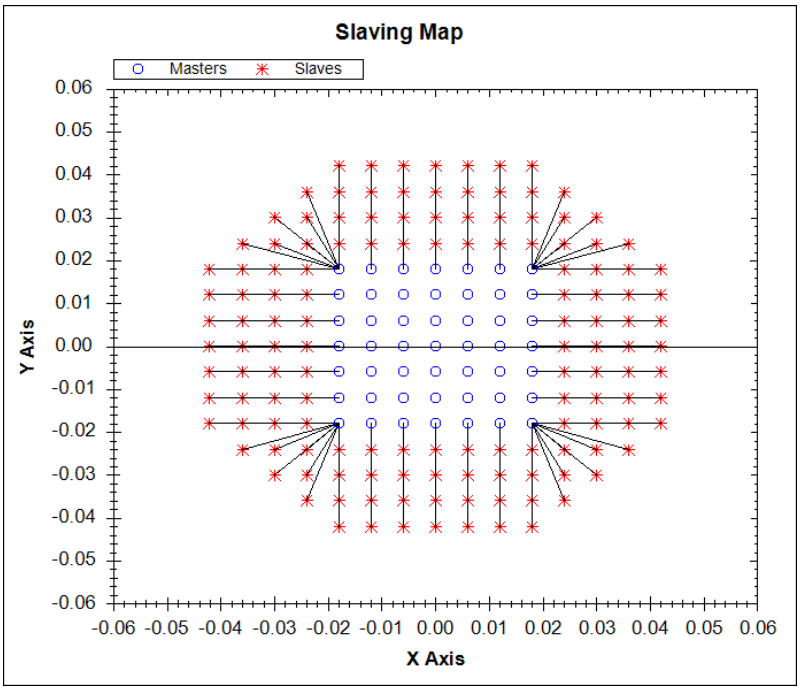

Figure 6: Slaving Map from the AOS CMG Software

Once the slaving map has been established, the control matrix is generated on the "Create Control Matrix" tab. Upon pushing the Make Control Matrix button, the SVD gains and the new control matrix is rendered by the software. Figure 7 shows a screenshot of this in the software with the button highlighted. We see in this result that there are not blank regions but instead are regions that are copied from their neighbors resulting in horizonal streaks in the control matrix. This illustrates that sets of actuators are receiving the same command

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as is expected from actuator slaving. This matrix can be saved from the CMG software and loaded into other adaptive optics software for use.

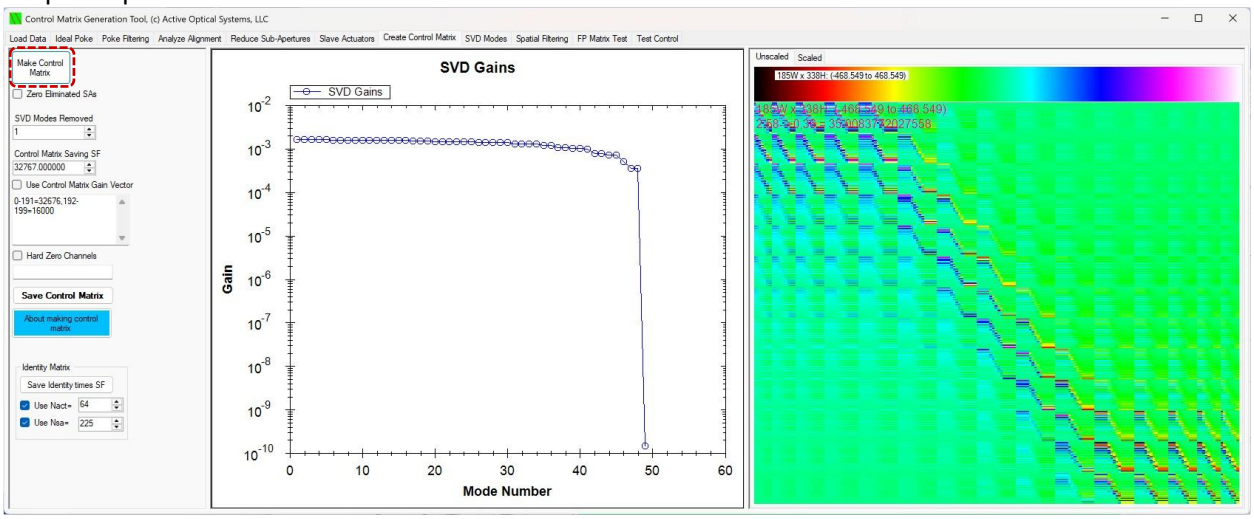

Figure 7: Control Matrix Generation with Slaving

3 Conclusions

There are many ways of overcoming poorly illuminated actuators in adaptive optics systems. This application note describes four of these ways and highlights the ease of implementation and potential pitfalls with each method. Slaving and grouping are the best methods. Disabling can be effective but only for low amplitude aberrations due to inter-actuator stroke limitations. SVD mode removal is fast in most software but can result in sub-optimal solutions.

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