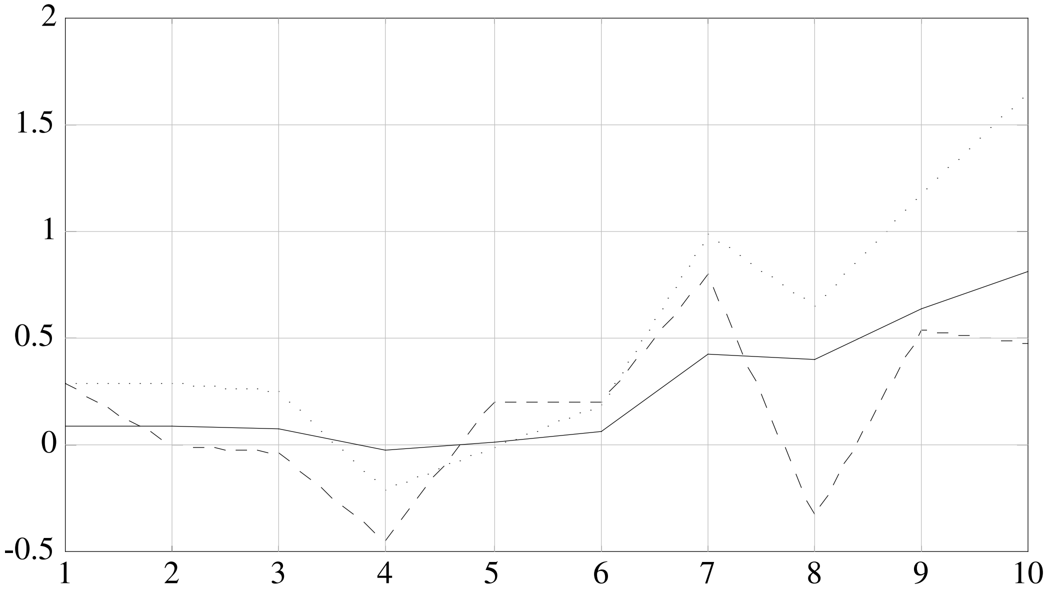

Figure 36. Recognition result with a noisy reverse Y-pattern. At time step 5, the cumulative difference is negative, yet due to the memory property of the hystery unit, its output is positive at time step 5.

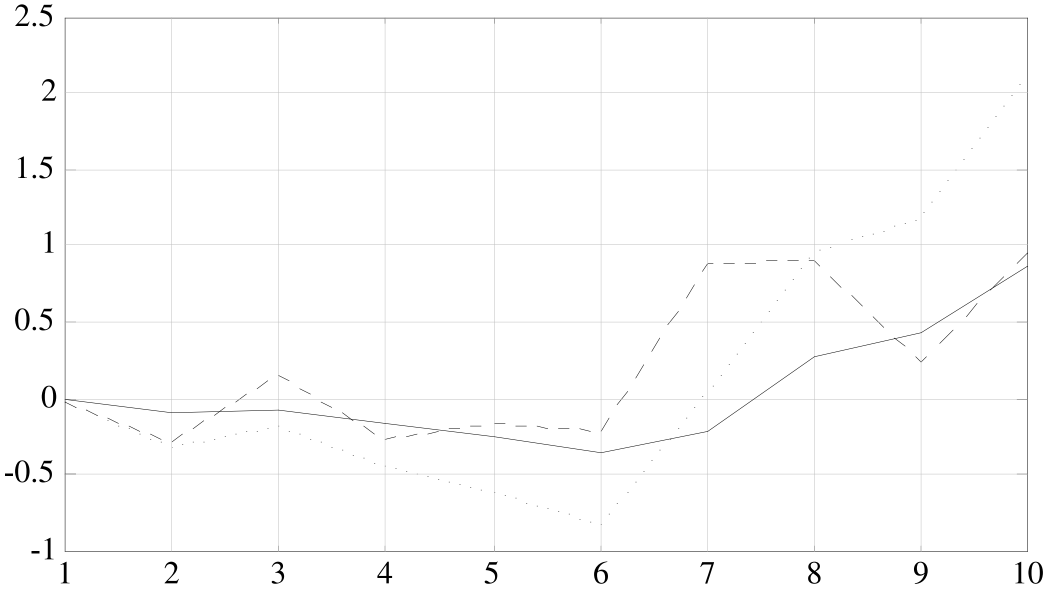

Figure 37. Recognition result with a noisy reverse Y-pattern path. At time step 7, evidence from the MIND unit drives the cumulative score positive, but due to the memory property of the hystery unit, its output is still negative at time step 7. Further correct MIND unit classifications give correct hystery unit output.

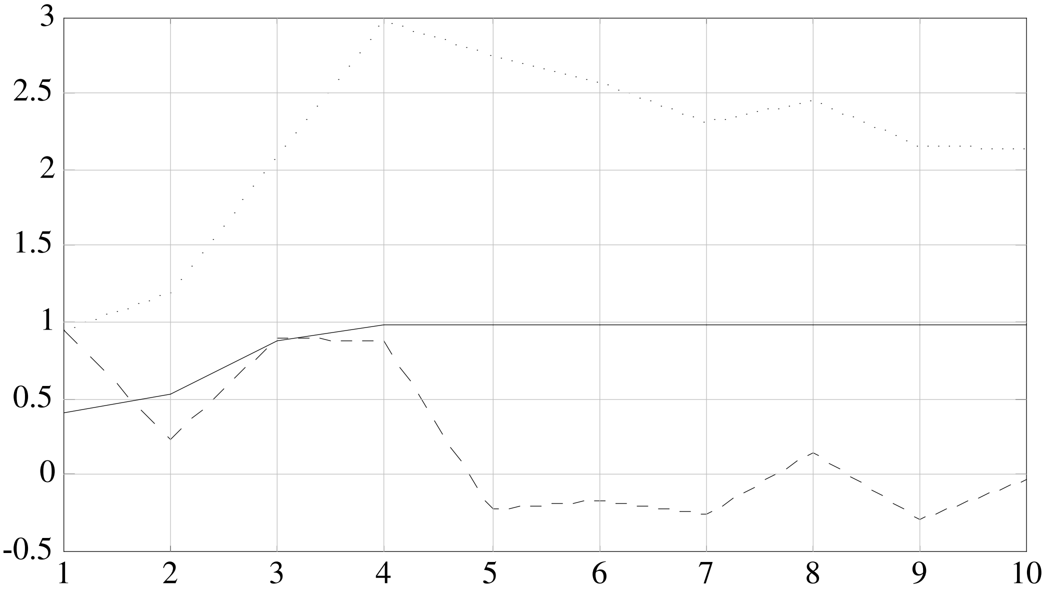

Figure 34. Recognition result of the other Y-pattern path that has decreasing magnitude. Note that at time steps 5, 6, 7, 9, and 10 the cumulative difference decreases to 3/4 of its peak value, yet the hystery unit holds on to its output value.

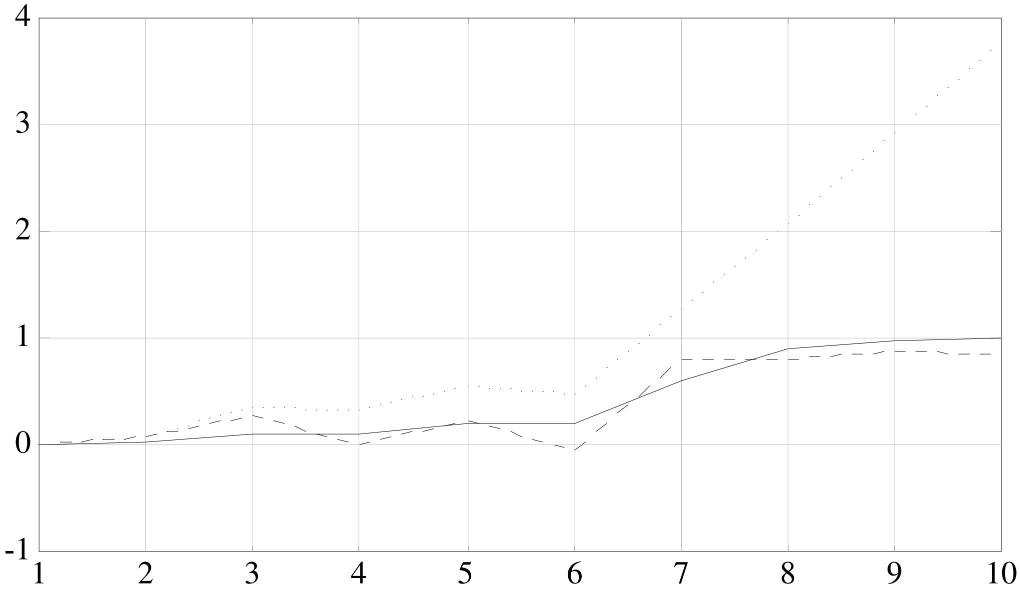

Figure 35. Recognition result with a typical reverse Y-pattern noisy path.

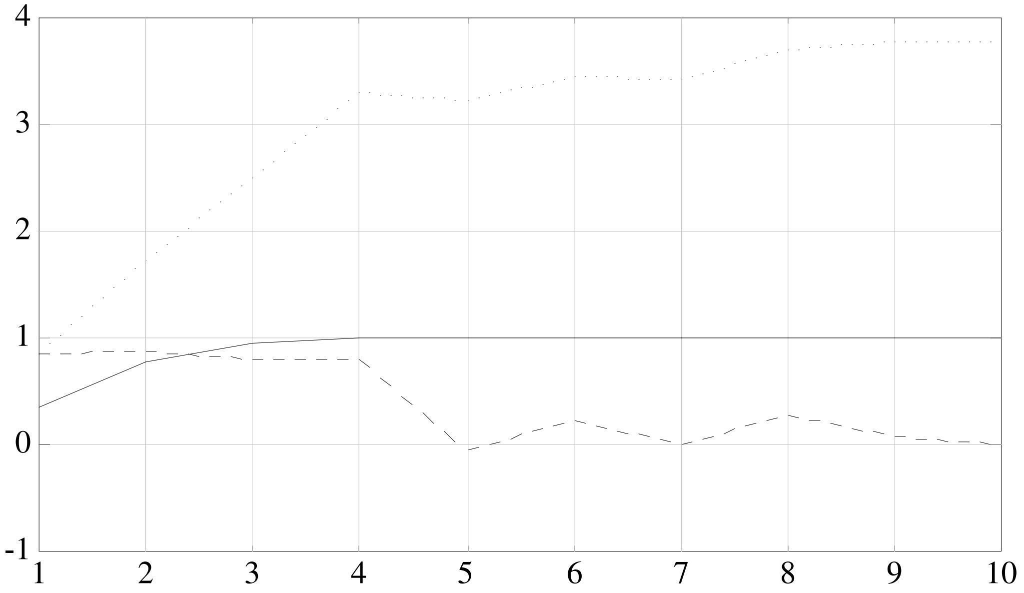

Figure 32. Recognition result with a noisy Y-pattern. The dashed line shows the difference between two MIND units trained on different paths. The dotted line shows the cumulative score of the difference. The solid line shows the output of the hystery unit.

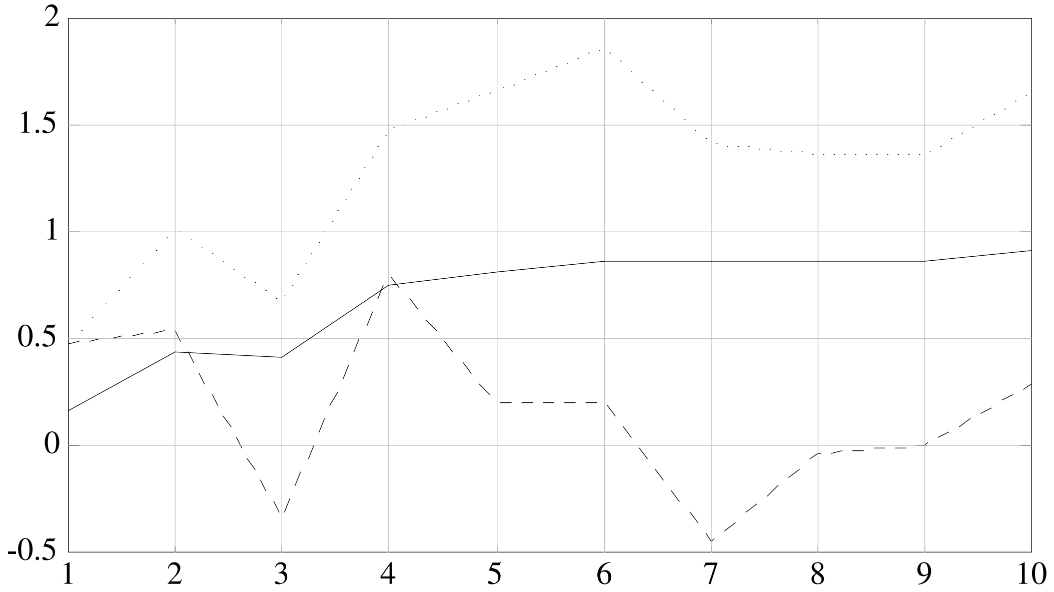

Figure 33. Recognition of a very noisy path of the Y-patterns. At time steps 3 and 7, the input sample is actually closer to the other path, causing the MIND unit to give a higher score for the other path. The cumulative difference decreases, yet the hystery unit's output is able to stay almost the same.

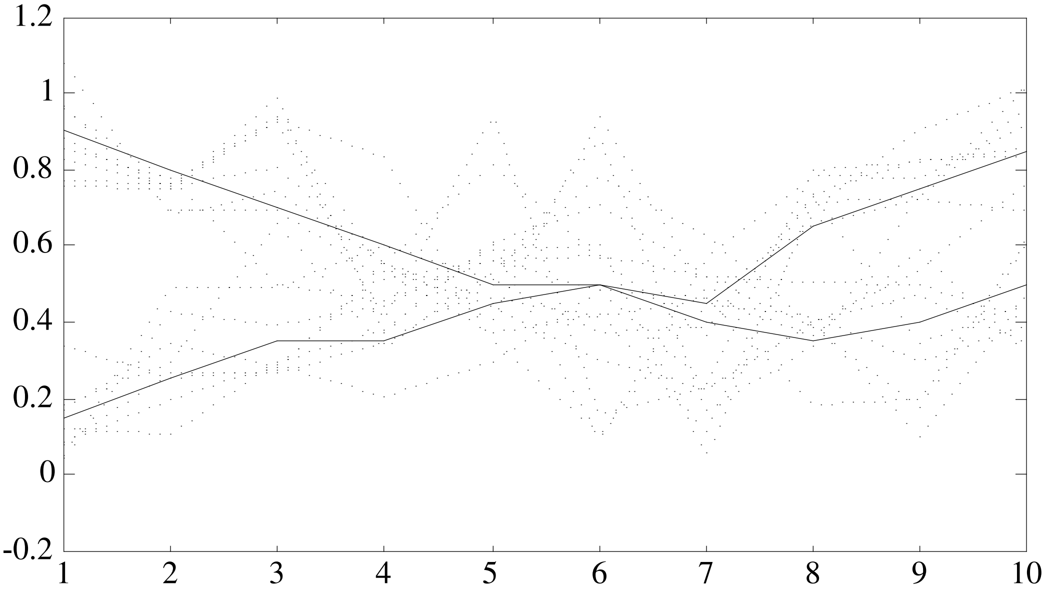

Figure 30. The X-patterns (solid line) and 9 noise corrupted X-patterns (dotted lines). The noise has a small variance in the beginning and at the end, but has a large variance in the middle. Note that the patterns are easily distinguishable just by looking at the beginning.

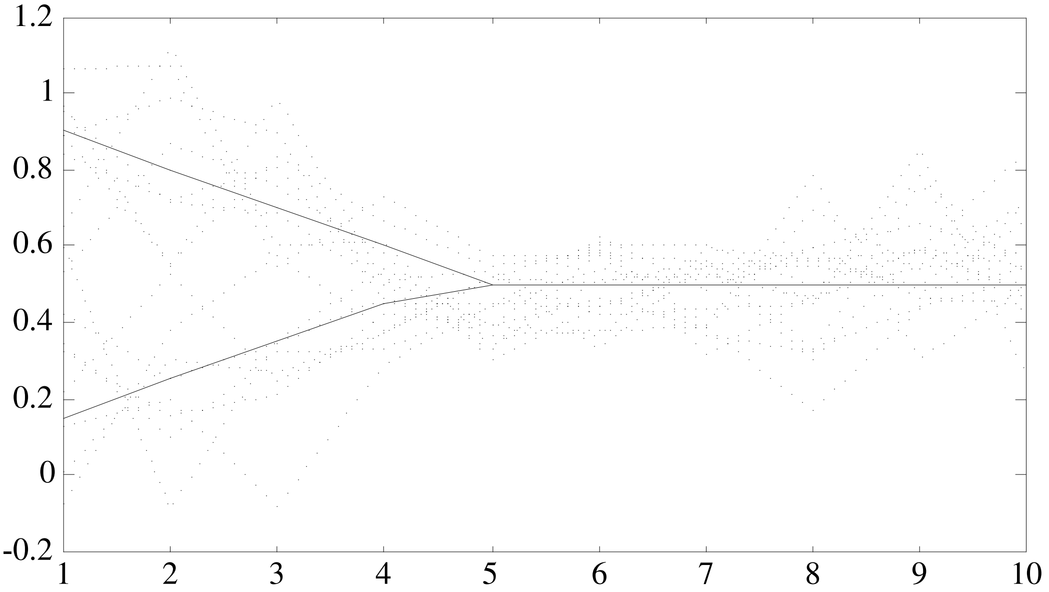

Figure 31. The Y-patterns (solid line) and 9 noise corrupted Y-patterns (dotted lines).

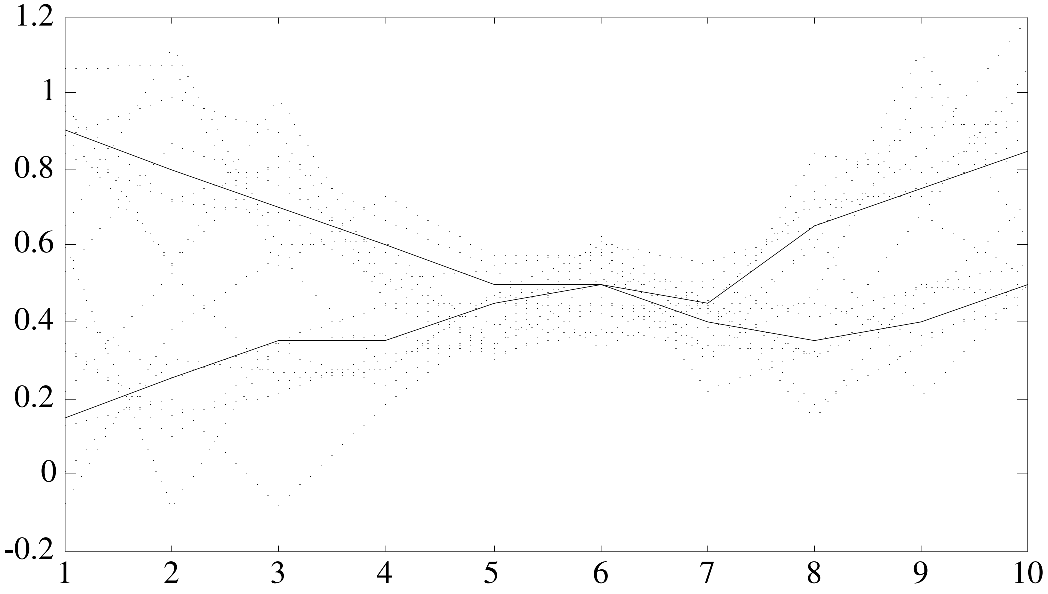

Figure 28. The X-patterns (solid line) and 9 noise corrupted X-patterns (dotted lines). The noise has a large variance in the beginning and at the end, but has a small variance in the middle.

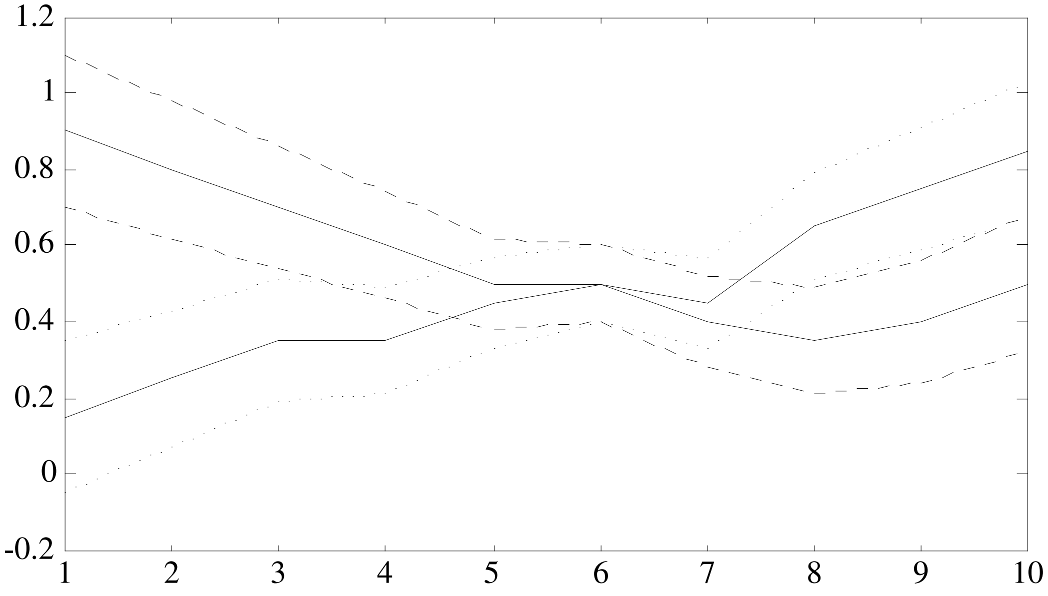

Figure 29. The X-patterns and the 1-standard deviation margin of the noise which has a large variance in the beginning and at the end, but small in the middle.

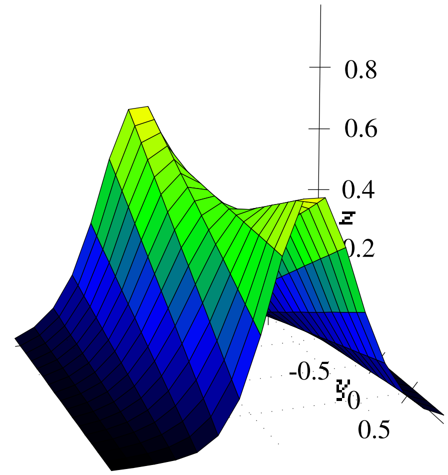

Figure 26. $z = y^{+}_{k+2} - y^{-}_{k+2}$ plotted over the x,y-plane with x ranging from -3 to 3 and y ranging from -1 to 1. Within this region, z is positive.

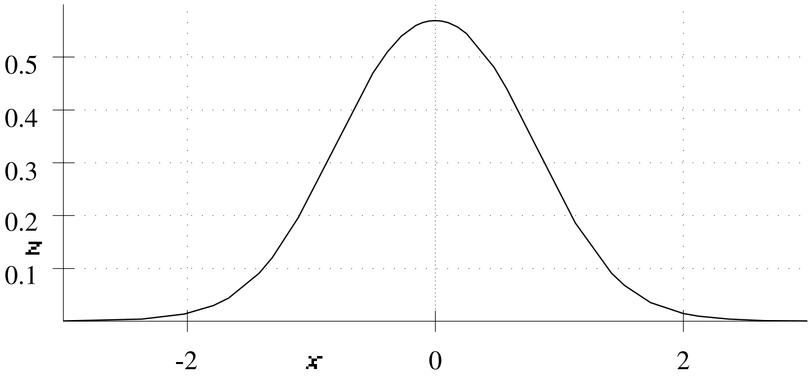

Figure 27. $z = y^{+}_{k+2} - y^{-}_{k+2}$ plotted along the curve through the origin (the "magnetization curve" of the hystery unit).

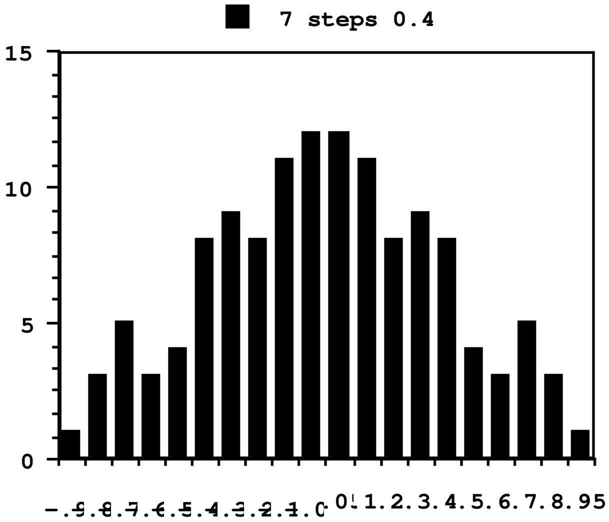

Figure 24. Density of the final output values for sequences of 7 quantized steps of step size 0.4.

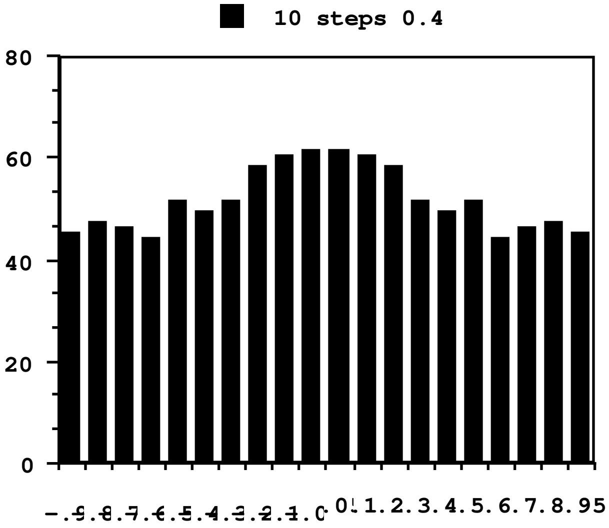

Figure 25. Density of the final output values for sequences of 10 quantized steps of step size 0.4.

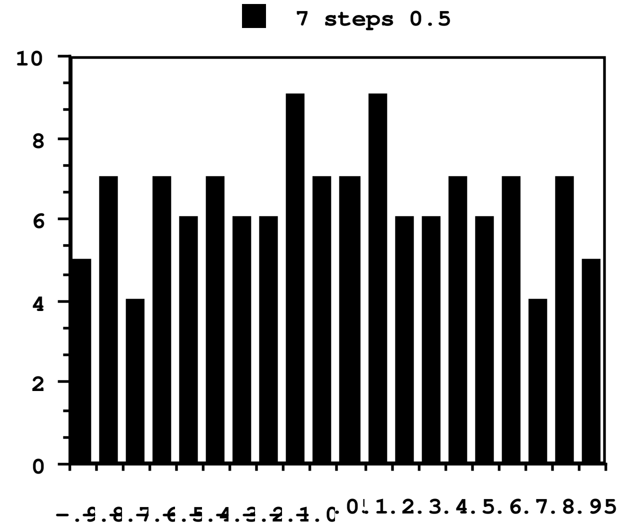

Figure 22. Density of the final output values for sequences of 7 quantized steps of step size 0.5.

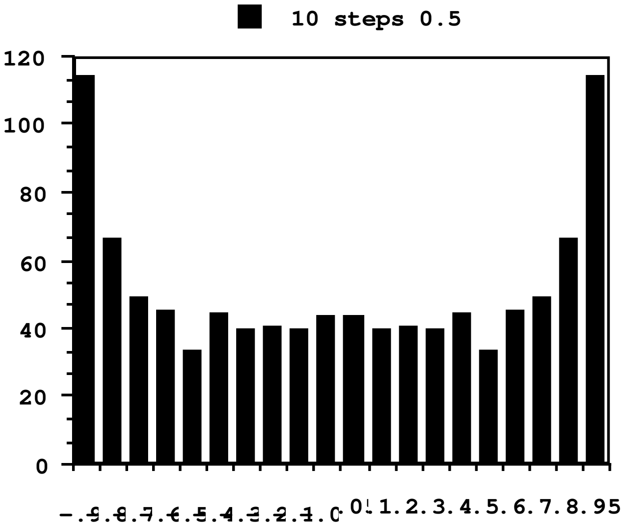

Figure 23. Density of the final output values for sequences of 10 quantized steps of step size 0.5.

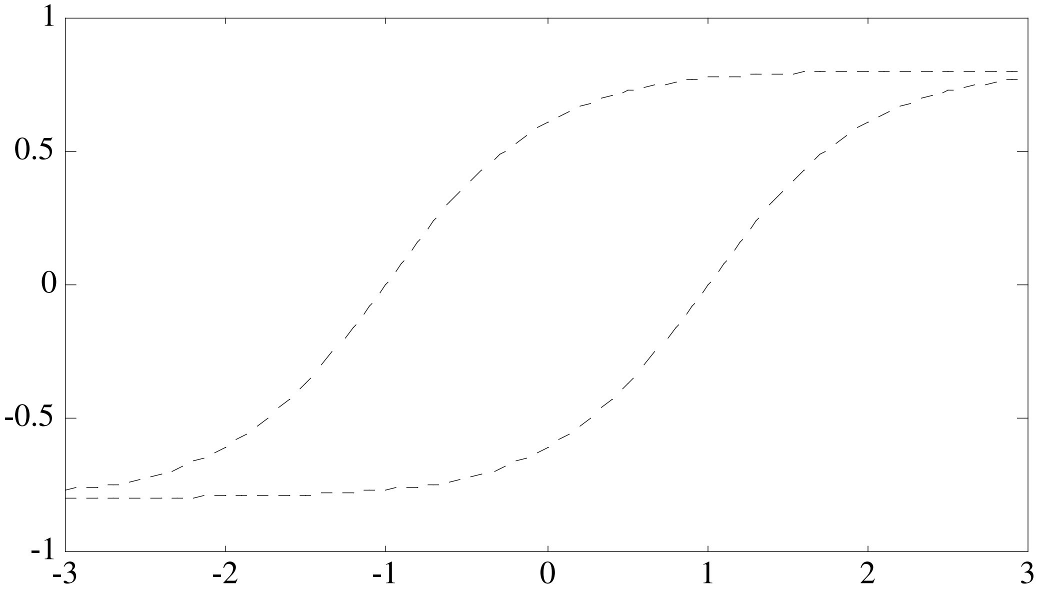

Figure 20. Final coordinates of all input sequences of 6 quantized steps. The step size is 0.5; Bs = 0.8; Hc = 1.

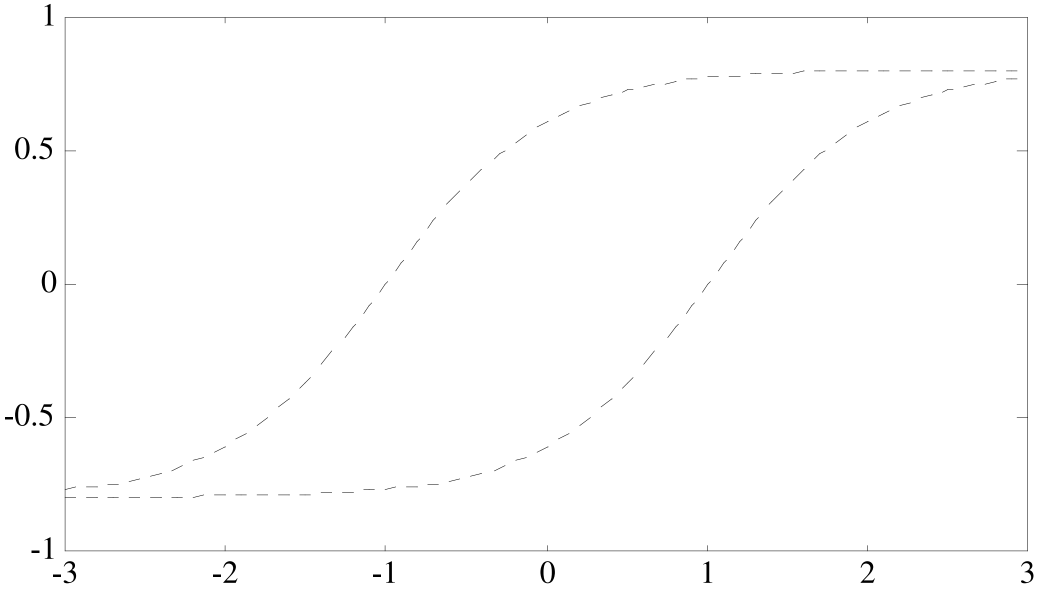

Figure 21. Final and intermediate coordinates of all input sequences of 5 quantized steps. The step size is 0.5; Bs = 0.8; Hc = 1.

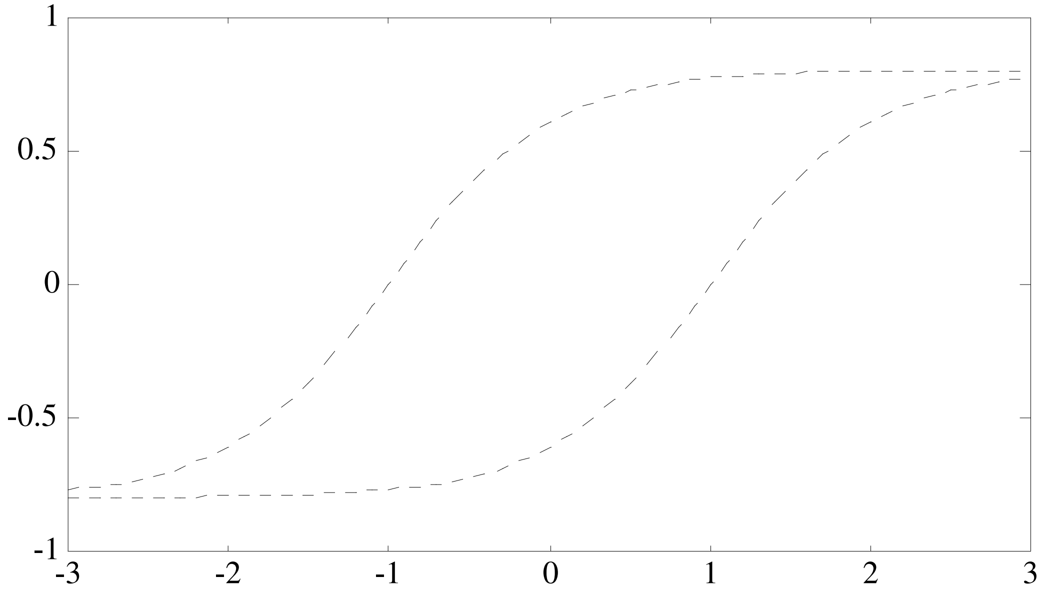

Figure 18. Final coordinates of all input sequences of 7 quantized steps.
The step size is 0.4; Bs = 0.8; Hc = 1.

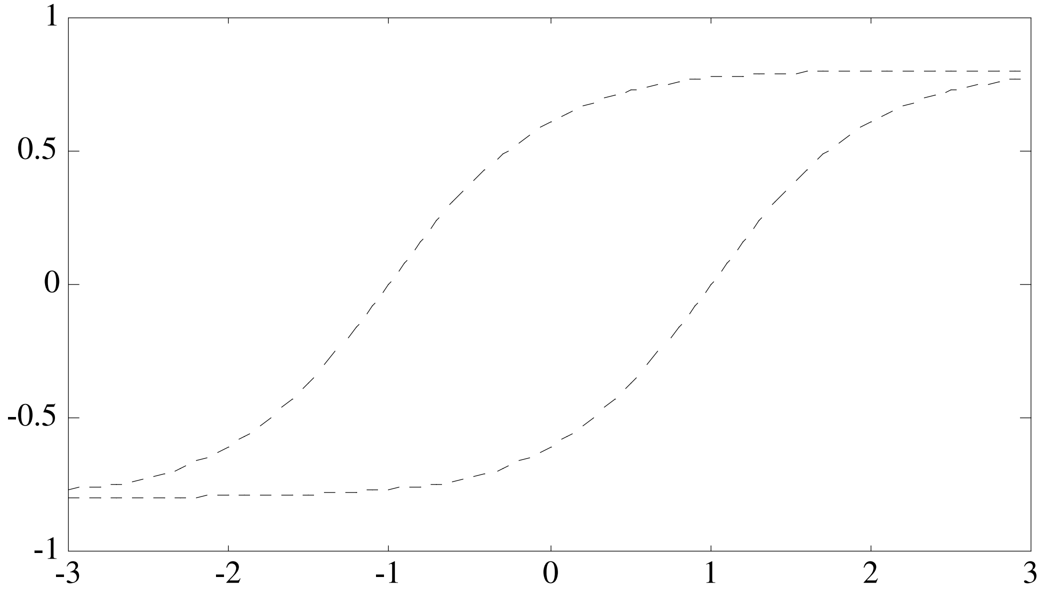

Figure 19. Final coordinates of all input sequences of 6 quantized steps.
The step size is 0.4; Bs = 0.8; Hc = 1.

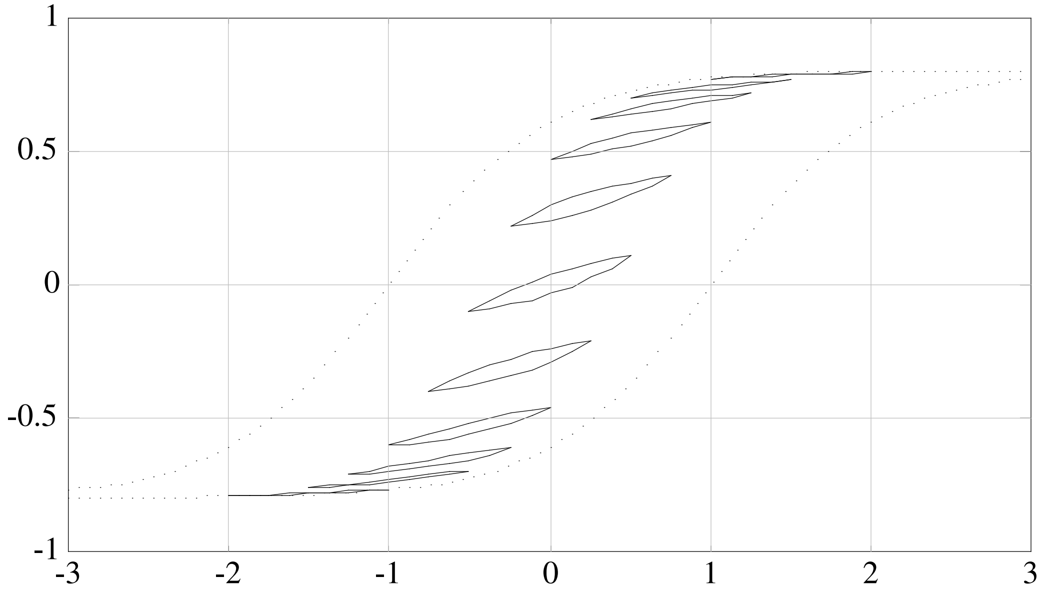

Figure 17. Several steady state loops of the hystery unit when driven by biased a.c. The magnitude is 0.5; Bs = 0.8; Hc = 1. The bottom through the top loops are driven by a.c. of bias -1.5, -1, -0.75, -0.5, -0.25, 0, 0.25, 0.5, 0.75, 1, and 1.5 respectively.

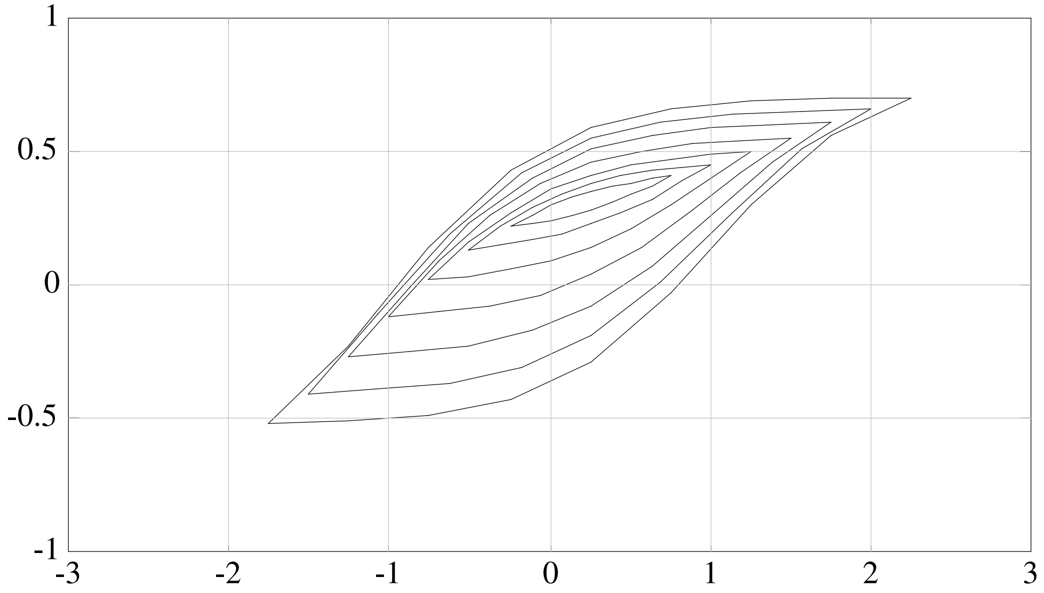

Figure 15. Several steady state loops of the hystery unit when driven by biased a.c. The bias is 0.25; Bs = 0.8; Hc = 1. The inner through the outer loops are driven by a.c. of magnitudes 0.5, 0.75, 1, 1.25, 1.5, 1.75, and 2 respectively.

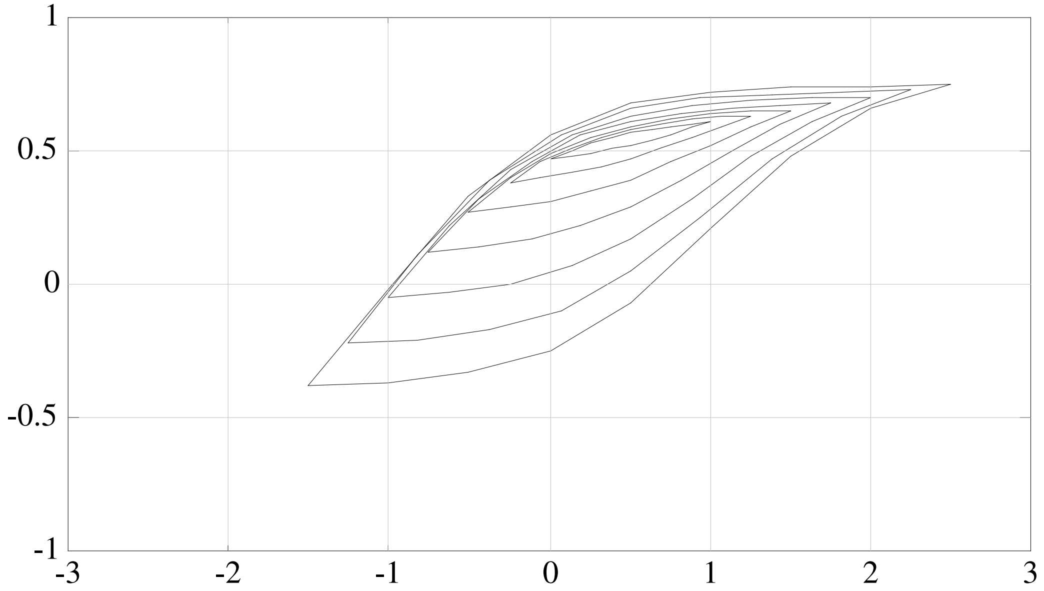

Figure 16. Several steady state loops of the hystery unit when driven by biased a.c. The bias is 0.5; Bs = 0.8; Hc = 1. The inner through the outer loops are driven by a.c. of magnitudes 0.5, 0.75, 1, 1.25, 1.5, 1.75, and 2 respectively.

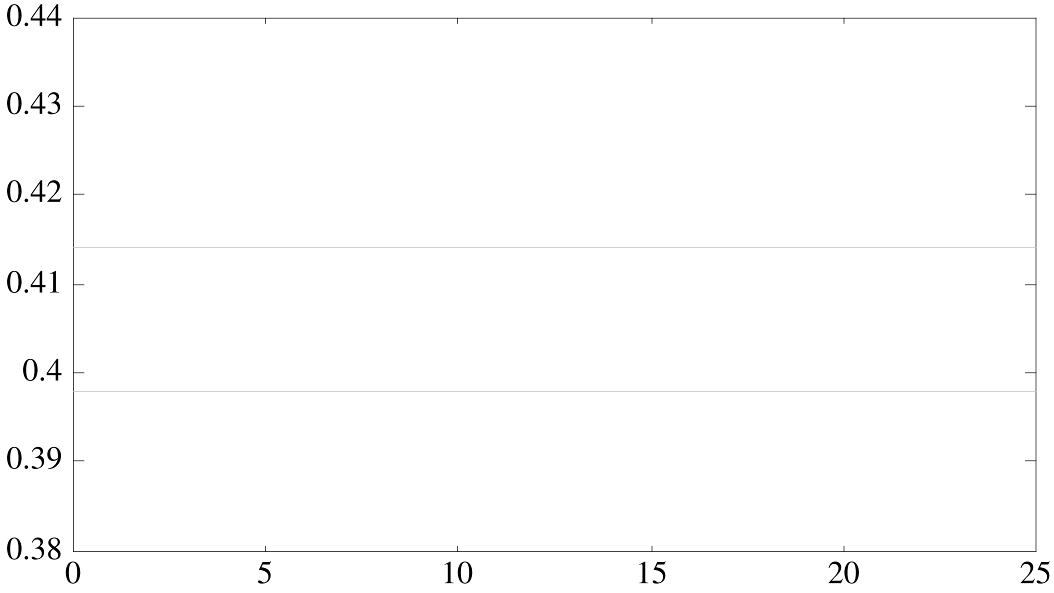

Figure 13. Convergence of the index into the family of curves under a bias of 0.01. The a.c. magnitude is 0.5; Bs = 1; Hc = 1; starting from (0,0).

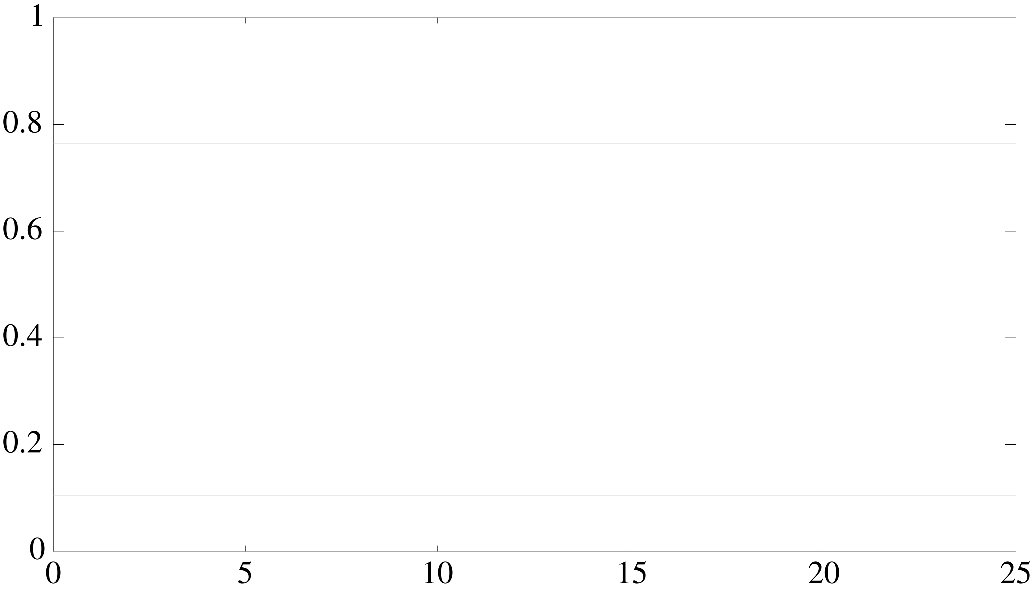

Figure 14. Convergence of the index into the family of curves under a bias of 0.5. The a.c. magnitude is 0.5; Bs = 1; Hc = 1; starting from (0,0).

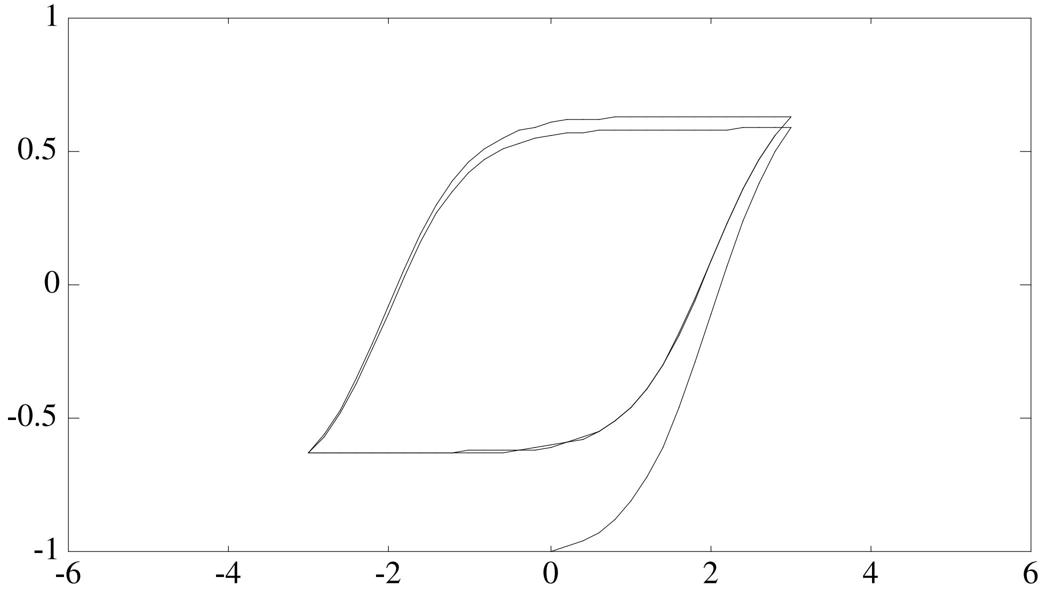

Figure 11. Convergence of the hystery unit when driven from (0,-1).
The amplitude of the a.c. input is 3; Bs = 0.8; Hc = 2.

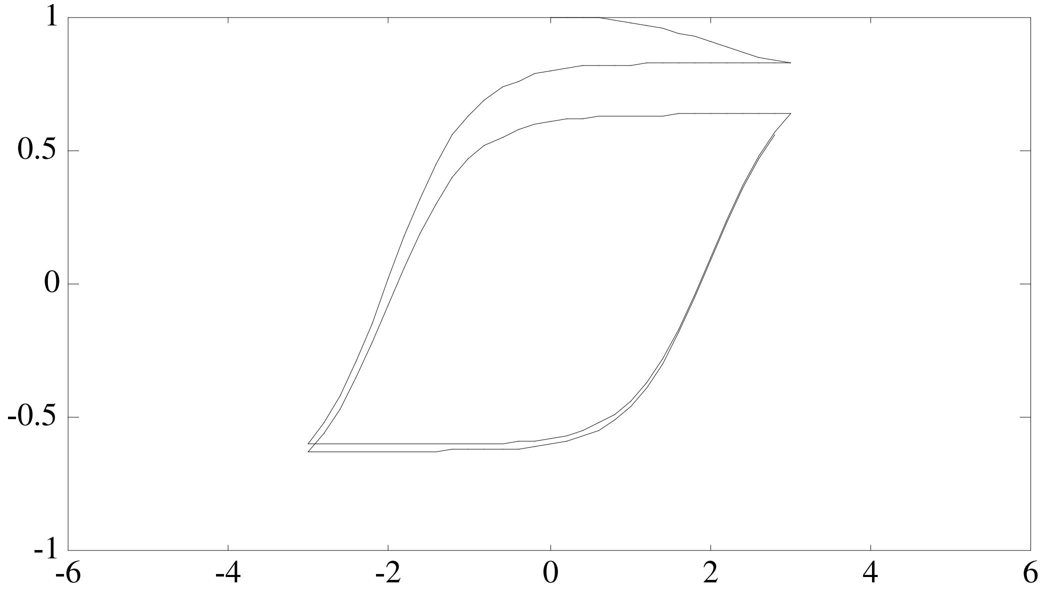

Figure 12. Convergence of the hystery unit when driven from (0,1).
The amplitude of the a.c. input is 3; Bs = 0.8; Hc = 2.

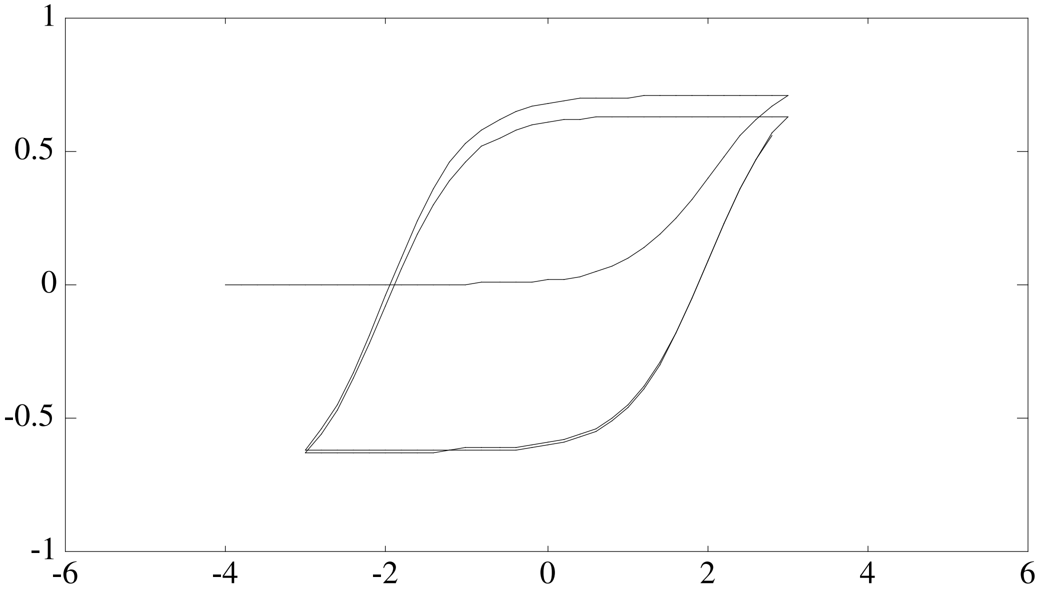

Figure 9. Convergence of the hystery unit when driven from (-4,0).
The amplitude of the a.c. input is 3; Bs = 0.8; Hc = 2.

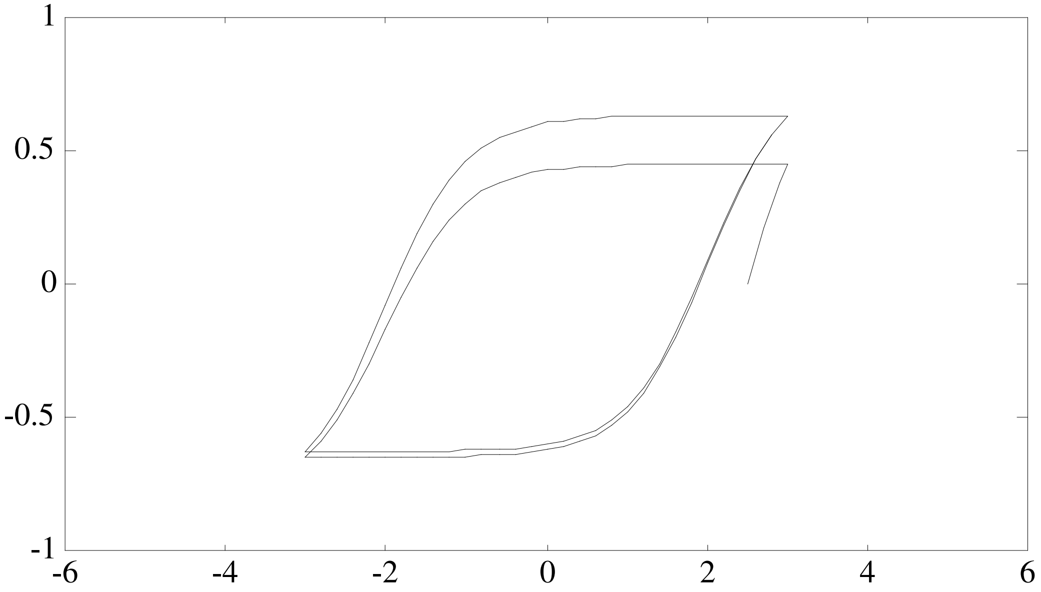

Figure 10. Convergence of the hystery unit when driven from (2.5,0).
The amplitude of the a.c. input is 3; Bs = 0.8; Hc = 2.

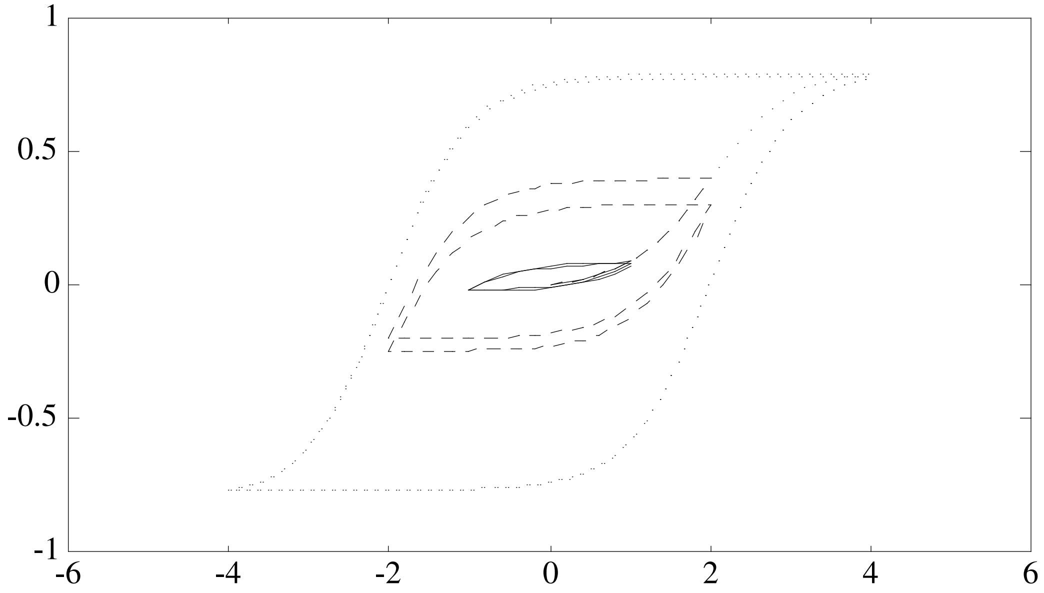

Figure 7. Convergence of the hystery unit under various a.c. input magnitudes.
The solid line, dashed line, and dotted line represent responds to a.c input
of magnitudes 1, 2, and 4 respectively. Bs = 0.8; Hc = 2.

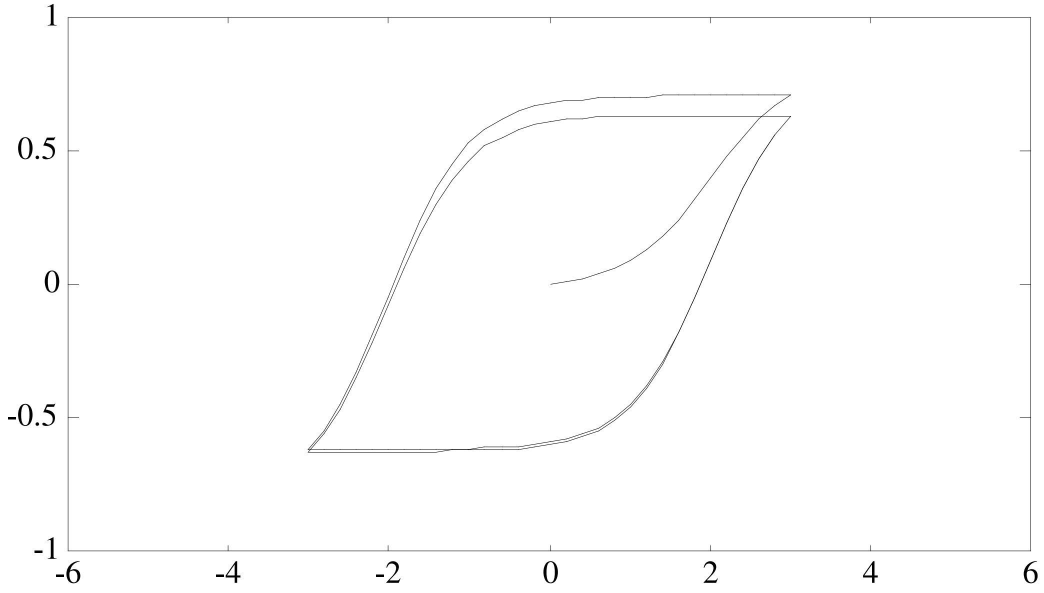

Figure 8. Convergence of the hystery unit when driven from (0,0).
The amplitude of the a.c. input is 3; Bs = 0.8; Hc = 2.

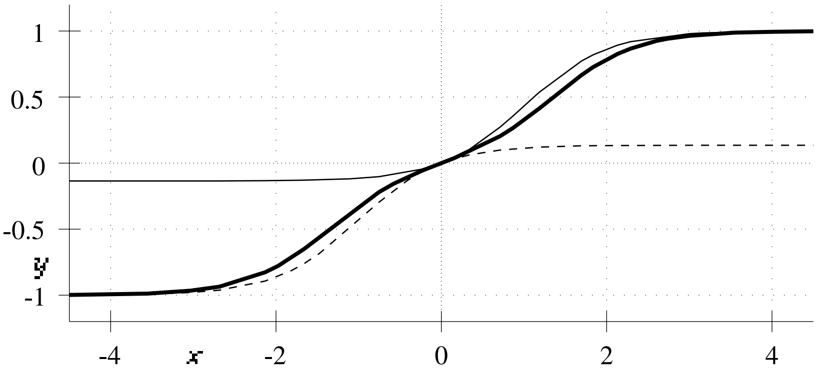

Figure 5. Magnetization curves: The heavy line shows the magnetization curve used in Model 3. The solid line and the dashed line show respectively the rising curve and falling curve of Model 4 which pass through the origin.

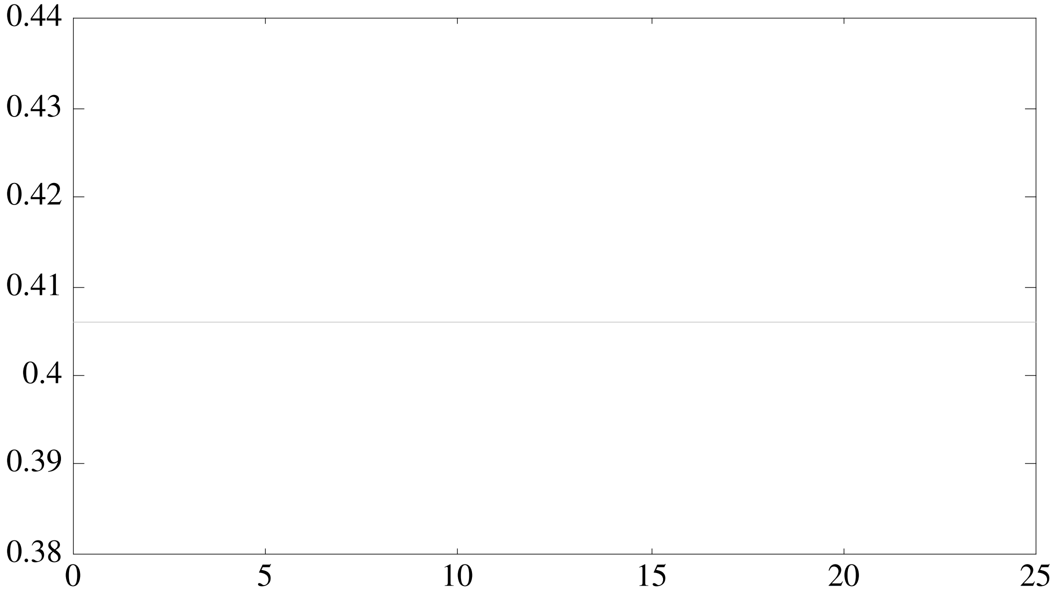

Figure 6. Convergence of the index into the family of curves under no bias. The a.c. magnitude is 0.5; Bs = 1; Hc = 1; starting from (0,0).

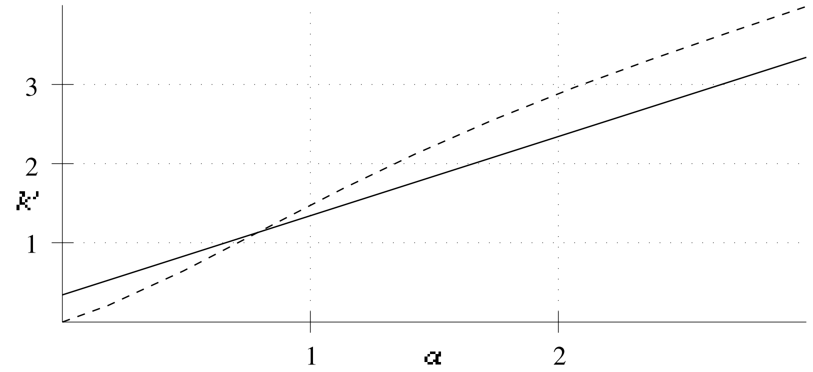

Figure 3. Measures of memory: The solid line shows the reverse input required to bring the output of Model 3 to the transition between the saturation region and the linear region, given the forward input is *a* and Hc = 1. The dashed line shows the reverse input required to bring the output to zero.

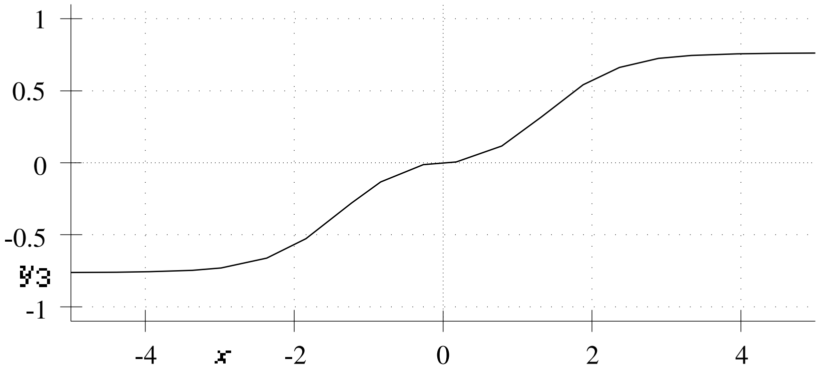

Figure 4. Residual memory: The graph shows the residual output of Model 3 when the input is reduced to zero after an input *x* is applied.

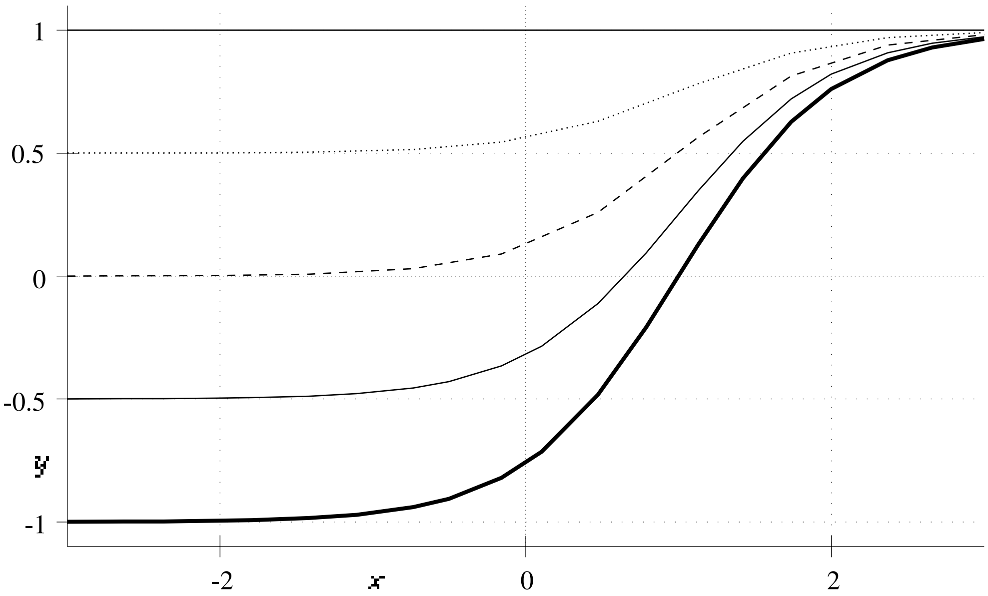

Figure 1. Five members of the family of rising curves. The thick line, solid line, dashed line, dotted line, and the solid line from bottom to top represent members with indices 0, 0.25, 0.5, 0.75, and 1 respectively.

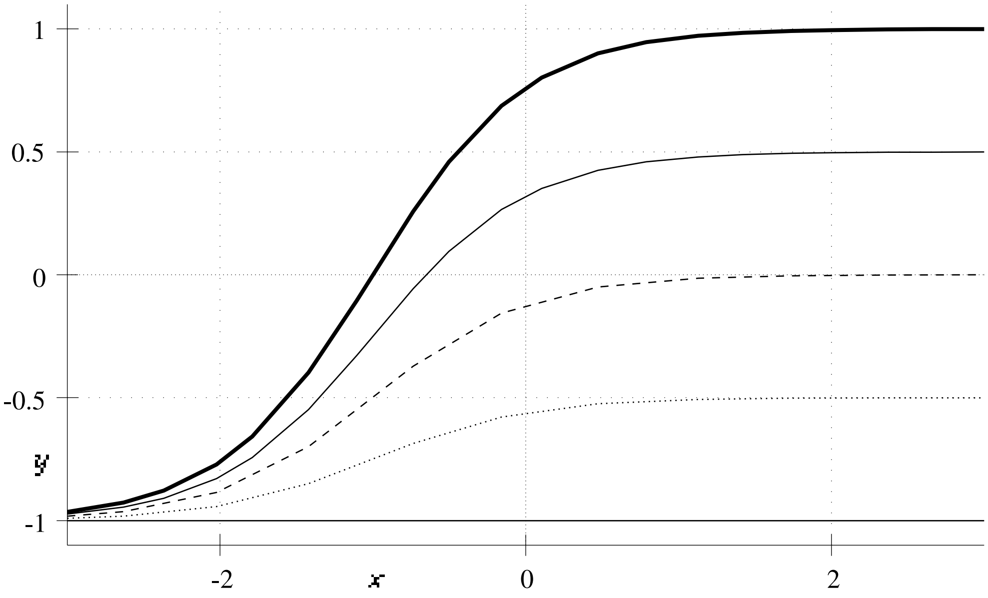

Figure 2. Five members of the family of falling curves. The thick line, solid line, dashed line, dotted line, and the solid line from top to bottom represent members with indices 0, 0.25, 0.5, 0.75, and 1 respectively.