

WHAT IS CLAIMED IS:

1. An apparatus for decoding video data, the apparatus comprising:
a memory configured to store the video data; and
one or more processors implemented in circuitry and configured to:
 decode a syntax element that indicates a manner in which to perform an
 adaptive loop filtering process, the syntax element indicating that a nonlinear
 operation is to be applied to the video data, the nonlinear operation configured to
 be applied in combination with a filtering operation of the adaptive loop filtering
 process; and
 perform the adaptive loop filtering process based on the syntax element.
2. The apparatus of claim 1, wherein the nonlinear operation comprises one or more
nonlinear operators that include one or more of: a shrinkage operator, a sigmoid function,
or a ReLU function.
3. The apparatus of claim 2, wherein the syntax element indicates cascaded versions
of the nonlinear operators.
4. The apparatus of claim 1, wherein the syntax element indicates parameters of the
nonlinear operation.
5. The apparatus of claim 1, wherein to perform the adaptive loop filtering process,
the one or more processors are configured to:
 determine an order for combining the nonlinear operation and the filtering
 operation, wherein the order includes applying the nonlinear operation followed by the
 filtering operation; and
 apply the nonlinear operation followed by the filtering operation.
6. The apparatus of claim 1, wherein to perform the adaptive loop filtering process,
the one or more processors are configured to:
 determine the nonlinear operation based on sample position, block size, sample
 value, or color component; and

apply the determined nonlinear operation to input samples of the adaptive loop filtering process.

7. The apparatus of claim 1, wherein the one or more processors are configured to apply the filtering operation of the adaptive loop filtering process in a plurality of filtering stages,

wherein the plurality of filtering stages include:

a first stage in which a pre-filtering operation is configured to be applied before the nonlinear operation, and

a second stage in which a post-filtering operation is configured to be applied after the nonlinear operation.

8. The apparatus of claim 7, wherein to perform the adaptive loop filtering process, the one or more processors are configured to:

determine that the nonlinear operation includes application of one or more clipping operators; and

apply the nonlinear operation following the pre-filtering operation.

9. The apparatus of claim 1, wherein to perform the adaptive loop filtering process, the one or more processors are configured to:

apply the combination of the filtering operation and the nonlinear operation to a reconstructed block of the video data to produce a filtered block of the video data; and

output the filtered block to a decoded picture buffer (DPB).

10. The apparatus of claim 1, wherein a pre-clipping operation precedes the adaptive loop filtering process, and wherein the nonlinear operation of the adaptive loop filtering process is separate from the pre-clipping operation.

11. The apparatus of claim 1, wherein the video data is one of a coding block of video data, a slice of video data, a tile of video data, a brick of video data, and/or a picture of video data.

12. The apparatus of claim 1, further comprising a display configured to display decoded video data following performance of the adaptive loop filtering process.

13. A method of decoding video data, the method comprising:

decoding a syntax element that indicates a manner in which to perform an adaptive loop filtering process, the syntax element indicating that a nonlinear operation is to be applied to the video data, the nonlinear operation configured to be applied in combination with a filtering operation of the adaptive loop filtering process; and
performing the adaptive loop filtering process based on the syntax element.

14. The method of claim 13, wherein the nonlinear operation comprises one or more nonlinear operators that include one or more of: a shrinkage operator, a sigmoid function, or a ReLU function.

15. The method of claim 14, wherein the syntax element indicates cascaded versions of the nonlinear operators.

16. The method of claim 13, wherein the syntax element indicates parameters of the nonlinear operation.

17. The method of claim 13, wherein performing the adaptive loop filtering process comprises:

determining an order for combining the nonlinear operation and the filtering operation, wherein the order includes applying the nonlinear operation followed by the filtering operation; and

applying the nonlinear operation followed by the filtering operation.

18. The method of claim 13, wherein performing the adaptive loop filtering process comprises:

determining the nonlinear operation based on sample position, block size, sample value, or color component; and

applying the determined nonlinear operation to input samples of the adaptive loop filtering process.

19. The method of claim 13, further comprising:
determining, based on side information, whether or not the filtering operation is adaptive; and
in response to the determination, enabling the adaptive loop filtering process.
20. The method of claim 13, further comprising:
applying the filtering operation of the adaptive loop filtering process in a plurality of filtering stages,
wherein the plurality of filtering stages include:
a first stage in which a pre-filtering operation is configured to be applied before the nonlinear operation, and
a second stage in which a post-filtering operation is configured to be applied after the nonlinear operation.
21. The method of claim 20, wherein performing the adaptive loop filtering process comprises:
determining that the nonlinear operation includes application of one or more clipping operators; and
applying the nonlinear operation following the pre-filtering operation.
22. The method of claim 13, wherein performing the adaptive loop filtering process comprises:
applying the combination of the filtering operation and the nonlinear operation to a reconstructed block of the video data to produce a filtered block of the video data; and
outputting the filtered block to a decoded picture buffer (DPB).
23. The method of claim 13, wherein a pre-clipping operation precedes the adaptive loop filtering process, and wherein the nonlinear operation of the adaptive loop filtering process is separate from the pre-clipping operation.
24. The method of claim 13, wherein the video data is one of a coding block of video data, a slice of video data, a tile of video data, a brick of video data, and/or a picture of video data.

25. An apparatus for encoding video data, the apparatus comprising:
a memory configured to store the video data; and
one or more processors implemented in circuitry and configured to:
determine a nonlinear operation and a filtering operation to perform in an adaptive loop filtering process;
perform the adaptive loop filtering process by applying the filtering operation and the nonlinear operation to the video data; and
encode a syntax element that indicates a manner in which the adaptive loop filtering process was performed.
26. The apparatus of claim 25, wherein to encode the syntax element, the one or more processors are configured to:
encode the syntax element to indicate the filtering operation or the nonlinear operation as a first operation of the adaptive loop filtering process.
27. The apparatus of claim 25, wherein to encode the syntax element, the one or more processors are configured to:
encode the syntax element to indicate a composition order for the filtering operation and the nonlinear operation.
28. An apparatus for decoding video data, the apparatus including:
means for decoding a syntax element that indicates a manner in which to perform an adaptive loop filtering process, the syntax element indicating that a nonlinear operation is to be applied to the video data, the nonlinear operation configured to be applied in combination with a filtering operation of the adaptive loop filtering process; and
means for performing the adaptive loop filtering process based on the syntax element.
29. The apparatus of claim 28, wherein the means for performing the adaptive loop filtering process comprises:
means for applying the nonlinear operation; and
means for applying the filtering operation following the nonlinear operation.

30. The apparatus of claim 28, further comprising:
means for applying the filtering operation of the adaptive loop filtering process in a plurality of filtering stages that are separated by the nonlinear operation.
31. The apparatus of claim 28, wherein the means for performing the adaptive loop filtering process comprises:
means for applying the nonlinear operation to a reconstructed block of the video data.
32. A non-transitory computer-readable storage medium having stored thereon instructions that, when executed, cause one or more processors to:
decode a syntax element that indicates a manner in which to perform an adaptive loop filtering process, the syntax element indicating that a nonlinear operation is to be applied to video data in combination with a filtering operation; and
perform the adaptive loop filtering process based on the syntax element.
33. The non-transitory computer-readable storage medium of claim 32, wherein the nonlinear operation comprises one or more nonlinear operators that include one or more of: a shrinkage operator, a sigmoid function, or a ReLU function.
34. The non-transitory computer-readable storage medium of claim 32, wherein the instructions, when executed, cause the one or more processors to:
apply the filtering operation and the nonlinear operation to a reconstructed block of the video data to produce a filtered block of the video data.
35. The non-transitory computer-readable storage medium of claim 32, wherein the instructions, when executed, cause the one or more processors to:
determine one or more filtering coefficients for the filtering operation; and
determine one or more parameters for the nonlinear operation.
36. The non-transitory computer-readable storage medium of claim 32, wherein the instructions, when executed, cause the one or more processors to:
determine an order for combining the nonlinear operation and the filtering operation.