Laboratory of Image Processing

Lane Departure Warning System

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Lane Departure Warning System

This example shows how to detect road lane markers in a video stream and how to highlights the lane in which the vehicle is driven. This information can be used to detect an unintended departure from the lane and issue a warning.

This example detects and tracks road lane markers in a video sequence and notifies the driver if they are moving across a lane. The example illustrates how to use the **`HoughTransform`**, **`HoughLines`** and **`LocalMaximaFinder`** System objects to create line detection and tracking algorithms.

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The example implements this algorithm using the following steps:

1. Detect lane markers in the current video frame.

2. Match the current lane markers with those detected in the previous video frame.

3. Find the left and right lane markers.

4. Issue a warning message if the vehicle moves across either of the lane markers.

To process low quality video sequences, where lane markers might be difficult to see or are hidden behind objects, the example waits for a lane marker to appear in multiple frames before it considers the marker to be valid. The example uses the same process to decide when to begin to ignore a lane marker.

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Initialization

Use these next sections of code to initialize the required variables and System objects.

```
DrawPoly = 1;  % Set to 0 to draw only lines
NumRows = 120; % Number of rows in the image region to process.
MaxLaneNum = 20; % Maximum number of lanes to store in the tracking
repository.
ExpLaneNum = 2;  % Maximum number of lanes to find in the current frame.
Rep_ref   = zeros(ExpLaneNum, MaxLaneNum); % Stored lines
Count_ref = zeros(1, MaxLaneNum);        % Count of each stored line
TrackThreshold = 75; % Maximum allowable change of lane distance
                     % metric between two frames.
LaneColors = single([0 0 0;1 1 0; 1 1 0; 1 1 1;1 1 1]);
% Minimum number of frames a lane must be detected to become a valid
lane.
frameFound = 5;
% Maximum number of frames a lane can be missed without marking it
invalid.
frameLost = 20;
```

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```
% For selecting Rho values 35:45 (1-based index: 415:424)
startIdxRho_R = 415;
NumRhos_R = 11;

% For selecting Theta values -90:-70deg (1-based index: 1:21)
startIdxTheta_R = 1;
NumThetas_R = 21;

% For selecting Rho values 379:415 (1-based index: 1:36)
startIdxRho_L = 380;
NumRhos_L = 36;

% For selecting Theta values 55:85deg (1-based index: 146:176)
startIdxTheta_L = 146;
NumThetas_L = 21;

% Offset for displaying the lines
offset = int32([0, NumRows, 0, NumRows]);
```

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Create a `VideoFileReader` System object to read video from a file.

```
hVideoSrc = vision.VideoFileReader('viplanedeparture.avi');
```

Create a `ColorSpaceConverter` System object to convert the RGB image to an intensity image.

```
hColorConv1 = vision.ColorSpaceConverter( ...
                    'Conversion', 'RGB to intensity');
```

Create a `ColorSpaceConverter` System object to convert the RGB image to a Y'CbCr image.

```
hColorConv2 = vision.ColorSpaceConverter( ...
                    'Conversion', 'RGB to YCbCr');
```

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Create an `ImageFilter` System object to implement a 2-D FIR filter to detect edges in the input video.

```
hFilter2D = vision.ImageFilter( ...
                    'Coefficients', [-1 0 1], ...
                    'OutputSize', 'Same as first input', ...
                    'PaddingMethod', 'Replicate', ...
                    'Method', 'Correlation');
```

Create an `Autothresholder` System object to convert the input intensity image to a binary image.

```
hAutothreshold = vision.Autothresholder;
```

Create a `HoughTransform` System object to find the lines defined by the lane markers.

```
hHough = vision.HoughTransform( ...
                    'ThetaRhoOutputPort', true, ...
                    'OutputDataType', 'single');
```

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Create `LocalMaximaFinder` System objects to find the peaks in the Hough transform output.

```
hLocalMaxFind1 = vision.LocalMaximaFinder( ...
                        'MaximumNumLocalMaxima', ExpLaneNum, ...
                        'NeighborhoodSize', [301 81], ...
                        'Threshold', 1, ...
                        'HoughMatrixInput', true, ...
                        'IndexDataType', 'uint16');
hLocalMaxFind2 = vision.LocalMaximaFinder( ...
                        'MaximumNumLocalMaxima', 1, ...
                        'NeighborhoodSize', [7 7], ...
                        'Threshold', 1, ...
                        'HoughMatrixInput', true, ...
                        'IndexDataType', 'uint16');
hLocalMaxFind3 = vision.LocalMaximaFinder( ...
                        'MaximumNumLocalMaxima', 1, ...
                        'NeighborhoodSize', [7 7], ...
                        'Threshold', 1, ...
                        'HoughMatrixInput', true, ...
                        'IndexDataType', 'uint16');
```

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Create `HoughLines` System objects to find the Cartesian coordinates of the lines defined by the lane markers.

```
hHoughLines1 = vision.HoughLines('SineComputation',
'Trigonometric function');
hHoughLines3 = vision.HoughLines('SineComputation',
'Trigonometric function');
```

define parameters for inserting lane departure warning text.

```
warnText = {sprintf('Right\nDeparture'), '', sprintf(' Left\n
Departure')};
warnTextLoc = [120 170;-1 -1; 2 170];
```

define parameters for inserting text specifying lane marker color/type.

```
lineText = {'', ...
        sprintf('Yellow\nBroken'), sprintf('Yellow
\nSolid'), ...
        sprintf('White\nBroken'), sprintf('White\nSolid')};
```

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Create a `videoPlayer` System object to display the output video.

```
hVideoOut = vision.VideoPlayer;
```

Initialize the variables used in the stream processing loop.

```
Frame = 0;
NumNormalDriving = 0;
OutMsg = int8(-1);
OutMsgPre = OutMsg;
Broken = false;
```

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Stream Processing Loop

Create the processing loop to perform lane detection on the input video. This loop uses the System objects you instantiated.

```
warningTextColors = {[1 0 0], [1 0 0], [0 0 0], [0 0 0]};
while ~isDone(hVideoSrc)
    RGB = step(hVideoSrc);

    % Select the lower portion of input video (confine field
of view)
    Imlow  = RGB(NumRows+1:end, :, :);

    % Edge detection and Hough transform
    Imlow = step(hColorConv1, Imlow); % Convert RGB to
intensity
    I = step(hFilter2D, Imlow);
    % Saturate the values to be between 0 and 1
    I(I < 0) = 0;
    I(I > 1) = 1;
    Edge = step(hAutothreshold, I);
    [H, Theta, Rho] = step(hHough, Edge);
```

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```
% Peak detection
    H1 = H;
    % Wipe out H matrix with theta < -78 deg and theta >= 78
deg
    H1(:, 1:12) = 0;
    H1(:, end-12:end) = 0;
    Idx1 = step(hLocalMaxFind1, H1);
    Count1 = size(Idx1,1);

    % Select Rhos and Thetas corresponding to peaks
    Line = [Rho(Idx1(:, 2)); Theta(Idx1(:, 1))];
    Enable = [ones(1,Count1) zeros(1, ExpLaneNum-Count1)];

% Track a set of lane marking lines
[Rep_ref, Count_ref] = videolanematching(Rep_ref, Count_ref, ...
                       MaxLaneNum, ExpLaneNum, Enable, Line, ...
                       TrackThreshold, frameFound+frameLost);
```

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```
 % Convert lines from Polar to Cartesian space.
Pts = step(hHoughLines1, Rep_ref(2,:), Rep_ref(1,:), Imlow);

% Detect whether there is a left or right lane departure.
[TwoValidLanes, NumNormalDriving, TwoLanes, OutMsg] = ...
   videodeparturewarning(Pts, Imlow, MaxLaneNum, Count_ref, ...
                                  NumNormalDriving, OutMsg);
% Meaning of OutMsg: 0 = Right lane departure,
%                    1 = Normal driving, 2 = Left lane departure

% Detect the type and color of lane marker lines
YCbCr  = step(hColorConv2, RGB(NumRows+1:240, :, :));
ColorAndTypeIdx = videodetectcolorandtype(TwoLanes, YCbCr);

  % Meaning of ColorAndTypeIdx:
     % INVALID_COLOR_OR_TYPE = int8(0);
     % YELLOW_BROKEN = int8(1); YELLOW_SOLID = int8(2);
     % WHITE_BROKEN = int8(3);  WHITE_SOLID = int8(4).
```

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```
 % Output
 Frame = Frame + 1;
if Frame >= 5
    TwoLanes1 = TwoLanes + [offset; offset]';
    if DrawPoly && TwoValidLanes
        if TwoLanes(4,1) >= 239
            Templ = TwoLanes1(3:4, 1);
        else
            Templ = [0 239]';
        end
        if TwoLanes(4,2) >= 239
            Tempr = TwoLanes1(3:4, 2);
        else
            Tempr = [359 239]';
        end
        Pts_poly = [TwoLanes1(:,1); Templ; Tempr; ...
            TwoLanes1(3:4,2); TwoLanes1(1:2,2)];

        % Draw Polygon for lane
        RGB = insertShape(RGB,'FilledPolygon',Pts_poly.',...
                          'Color',[0 1 1],'Opacity',0.2);
    end
```

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```
  % Draw lane marker lines
        RGB = insertShape(RGB,'Line',TwoLanes1',...
            'Color',{'yellow','magenta'});
  % Insert Departure warning text (empty text will not be drawn)
        txt = warnText{OutMsg+1};
        txtLoc = warnTextLoc(OutMsg+1, :);
        txtColor = single(warningTextColors{mod(Frame-1,4)+1});
 RGB = insertText(RGB,txtLoc,txt,'TextColor', txtColor, ...
                              'FontSize',20, 'BoxOpacity', 0);


 % Insert text indicating type and color of left and right lanes
       for ii=1:2
           % empty text will not be drawn
          txtLoc = TwoLanes1([1 2], ii)' + int32([0 -35]);
          lineTxt = lineText{ColorAndTypeIdx(ii)};
          txtColor = LaneColors(ColorAndTypeIdx(ii), :);
          RGB =
insertText(RGB,txtLoc,lineTxt,'TextColor',txtColor, ...
                              'FontSize',14, 'BoxOpacity', 0);
       end
```

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```
% Draw third lane if needed
      if OutMsgPre ~= OutMsg
          ColorType = ColorAndTypeIdx(2-(OutMsg == 2));
          Broken    = ColorType == 2 || ColorType == 4;
      end
      ShowThirdLane = Broken && (OutMsg~=1);
      if ShowThirdLane
          if OutMsg == 0
              % Find right third lane
           Idx2 = step(hLocalMaxFind2, ...
           H(startIdxRho_R:startIdxRho_R+NumRhos_R-1, ...
           startIdxTheta_R:startIdxTheta_R+NumThetas_R-1));
           Rhor = Rho(Idx2(:,2) + startIdxRho_R);
           Thetar = Theta(Idx2(:,1) + startIdxTheta_R);
           ThirdLane = step(hHoughLines3, Thetar, Rhor, Imlow);
```

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```
    else
        % Find left third lane
        Idx3 = step(hLocalMaxFind3, ...
                H(startIdxRho_L:startIdxRho_L+NumRhos_L-1 , ...
                startIdxTheta_L:startIdxTheta_L+NumThetas_L-1));
            Rhol = Rho(Idx3(:,2) + startIdxRho_L);
            Thetal = Theta(Idx3(:,1) + startIdxTheta_L);
            ThirdLane = step(hHoughLines3, Thetal, Rhol, Imlow);
        end

  OutThirdLane = videoexclude3rdlane(ThirdLane, ShowThirdLane,...
                                TwoLanes, TwoValidLanes, YCbCr);
    OutThirdLane = OutThirdLane(:) + offset(:);
    RGB = insertShape(RGB,'Line',OutThirdLane.','Color','green');
 end
end
```

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```
    OutMsgPre = OutMsg;

        step(hVideoOut, RGB);     % Display video
    end
```

Release

Here you call the release method on the System objects to close any open files and devices.

```
release(hVideoSrc);
```

Summary

In the Video Player window, you can see that the example detected the lane in front of the vehicle and drew a cyan polygon to mark its location. The example also indicates when the vehicle departs from its lane and the type of the lane marker lines detected.

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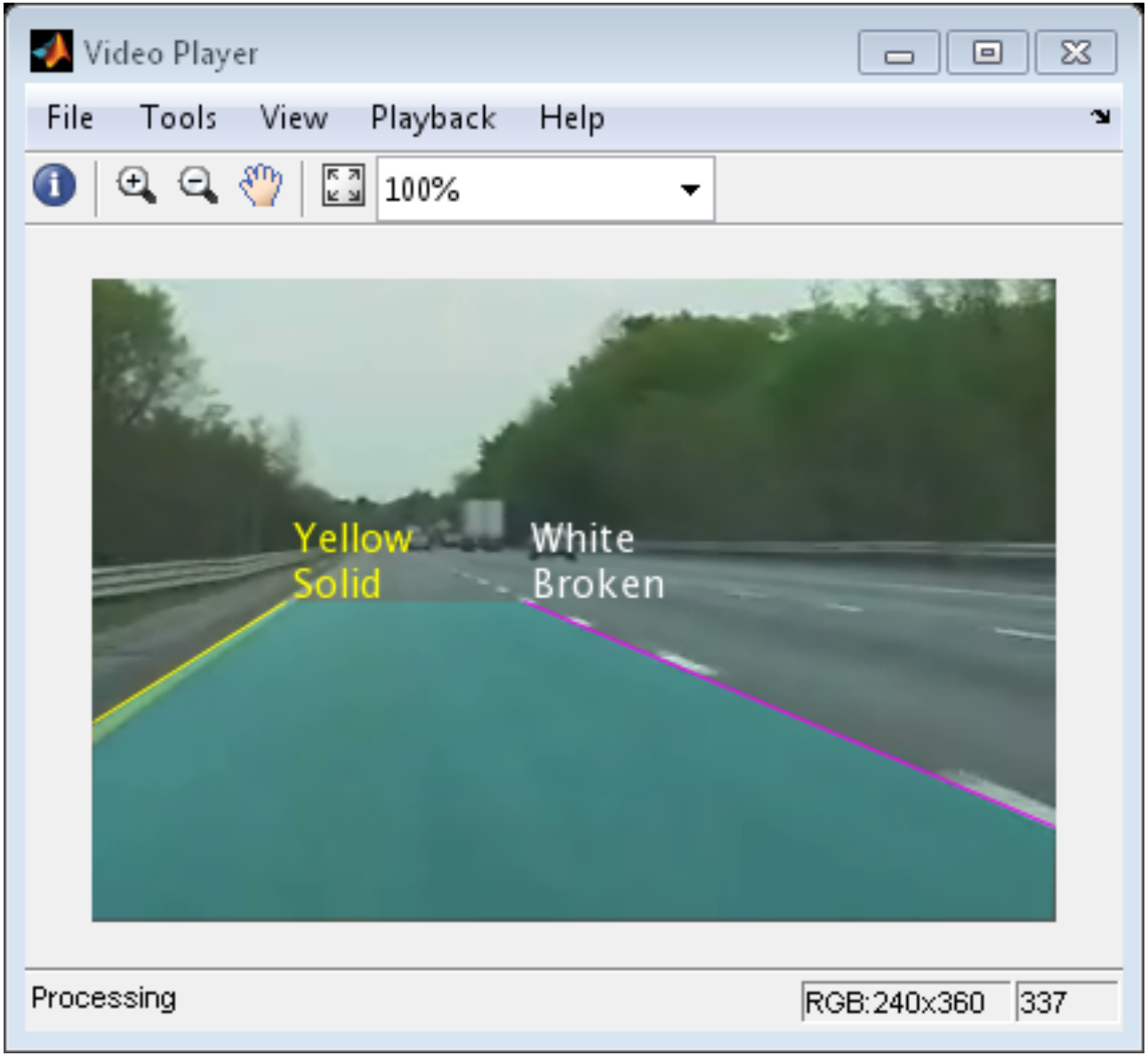

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Appendix

The following helper functions are used in this example.

videolanematching.m
videodepartureWarning.m
videodetectcolorandtype.m
videoexclude3rdlane.m