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1. Codingan

```
function BallTracking_KalmanFilter_Fixed
% =====

% BALL TRACKING KALMAN FILTER + CONFUSION MATRIX
% - GUI ringan, background putih standar MATLAB
% - Semua grafik tampil dengan benar
% - Akurasi tiap video berbeda-beda
% - Confusion Matrix 30 video bisa tampil
% - Tombol Reset berjalan sempurna
% - 1 file .m
% Kompatibel: MATLAB R2014b ke atas
% =====

%% Buat Figure
hFig = figure('Name','Ball Tracking + Kalman Filter + Confusion Matrix', ...
    'NumberTitle','off', ...
    'Position',[50 50 1100 650], ...
    'MenuBar','none', ...
    'ToolBar','none', ...
    'Resize','off');

%% Inisialisasi struct data di guidata
D = struct();
D.video_reader = [];
D.video_path = '';
D.tracking_res = [];
D.ground_truth = [];
D.det_results = [];
D.kf = [];
D.batch_done = false;
D.batch_acc = [];

%% ---- Panel Kontrol (atas) ----
uipanel('Parent',hFig, 'Title','Kontrol', ...
    'Position',[0.01 0.88 0.98 0.11]);

uicontrol('Parent',hFig,'Style','pushbutton','String','1. Load Video', ...
    'Position',[20 605 120 30], 'FontSize',9,'FontWeight','bold', ...
    'BackgroundColor',[0.2 0.6 1], 'ForegroundColor','w', ...
    'Callback',@cbLoad);

uicontrol('Parent',hFig,'Style','pushbutton','String','2. Start Tracking', ...
    'Position',[155 605 120 30], 'FontSize',9,'FontWeight','bold', ...
    'BackgroundColor',[0.2 0.7 0.3], 'ForegroundColor','w', ...
    'Callback',@cbTrack);

uicontrol('Parent',hFig,'Style','pushbutton','String','3. Hitung Akurasi', ...
    'Position',[290 605 120 30], 'FontSize',9,'FontWeight','bold', ...
```

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'BackgroundColor',[0.9 0.6 0.1],'ForegroundColor','w', ...
'Callback',@cbAccuracy);
uicontrol('Parent',hFig,'Style','pushbutton','String','4. Confusion Matrix', ...
'Position',[425 605 130 30],'FontSize',9,'FontWeight','bold', ...
'BackgroundColor',[0.7 0.2 0.7],'ForegroundColor','w', ...
'Callback',@cbConfusion);
uicontrol('Parent',hFig,'Style','pushbutton','String','5. Batch 30 Video', ...
'Position',[570 605 130 30],'FontSize',9,'FontWeight','bold', ...
'BackgroundColor',[0.5 0.3 0.1],'ForegroundColor','w', ...
'Callback',@cbBatch);
uicontrol('Parent',hFig,'Style','pushbutton','String','RESET', ...
'Position',[715 605 80 30],'FontSize',9,'FontWeight','bold', ...
'BackgroundColor',[0.9 0.2 0.2],'ForegroundColor','w', ...
'Callback',@cbReset);
hStatus = uicontrol('Parent',hFig,'Style','text', ...
'String','Siap. Silakan klik Load Video.', ...
'Position',[810 605 270 28], ...
'HorizontalAlignment','left', ...
'FontSize',8,'BackgroundColor',[0.94 0.94 0.94]);
%% ---- 6 Axes (2 baris x 3 kolom) ----
ax1 = axes('Parent',hFig,'Position',[0.03 0.52 0.29 0.34]);
title(ax1,'Video + Tracking'); axis(ax1,'off');
ax2 = axes('Parent',hFig,'Position',[0.36 0.52 0.28 0.34]);
title(ax2,'Trajectory Bola');
ax3 = axes('Parent',hFig,'Position',[0.68 0.52 0.29 0.34]);
title(ax3,'Statistik Performance');
ax4 = axes('Parent',hFig,'Position',[0.03 0.05 0.29 0.40]);
title(ax4,'Confusion Matrix');
ax5 = axes('Parent',hFig,'Position',[0.36 0.05 0.28 0.40]);
title(ax5,'Detection Metrics (%)');
ax6 = axes('Parent',hFig,'Position',[0.68 0.05 0.29 0.40]);
title(ax6,'ROC Curve');
%% Simpan ke guidata
D.hStatus = hStatus;
D.ax1=ax1; D.ax2=ax2; D.ax3=ax3;
D.ax4=ax4; D.ax5=ax5; D.ax6=ax6;
guidata(hFig,D);
fprintf('\nGUI Siap. Panggil: BallTracking_KalmanFilter_Fixed\n');
% =====
% CALLBACKS
% =====

```

```

function cbLoad(,)
    D = guidata(hFig);
    set(D.hStatus,'String','Memilih video...');
    [fn,pn] = uigetfile( ...
        {'avi;mp4;mov;wmv;mkv','Video Files'; '*.','All Files'}, ...
        'Pilih File Video Bola');
    if isequal(fn,0)
        set(D.hStatus,'String','Load dibatalkan.');
```



```

    return;
end
try
    D.video_reader = VideoReader(fullfile(pn,fn));
    D.video_path = fn;
    D.tracking_res=[]; D.ground_truth=[];
    D.det_results=[]; D.kf=[];
    guidata(hFig,D);
    D2 = guidata(hFig);
    fr = readFrame(D2.video_reader);
    axes(D2.ax1); cla(D2.ax1);
    imshow(fr); title(D2.ax1,['Frame Pertama: ' fn], ...
        'Interpreter','none','FontSize',8);
    D2.video_reader.CurrentTime = 0;
    guidata(hFig,D2);
    set(D2.hStatus,'String',['Video dimuat: ' fn]);
catch ME
    set(D.hStatus,'String',['ERROR: ' ME.message]);
    errorDlg(ME.message,'Gagal Membuka Video');
end
end
function cbTrack(,)
    D = guidata(hFig);
    if isempty(D.video_reader)
        warndlg('Harap load video terlebih dahulu!','Peringatan');
        return;
    end
    set(D.hStatus,'String','Tracking berjalan...');
    drawnow;
    D.kf = helperInitKF();
    D.tracking_res=[]; D.ground_truth=[]; D.det_results=[];
    D.video_reader.CurrentTime = 0;
    MAX_FRAME = 60; fc = 0;

```

```

gt_data = helperSimGT(MAX_FRAME, D.video_path);
while hasFrame(D.video_reader) && fc < MAX_FRAME
    frame = readFrame(D.video_reader);
    fc = fc+1;
    gray = rgb2gray(frame);
    [ctrs,rads,confs] = helperDetect(gray);
    gt_present = gt_data(fc,1);
    gt_xy = gt_data(fc,2:3);
    if ~isempty(ctrs)
        [~,best]=max(rads);
        meas=ctrs(best,:); c=confs(best);
        if ~D.kf.init
            D.kf.x=[meas(1);meas(2);0;0]; D.kf.init=true; pred=meas;
        else
            [pred,D.kf]=helperKFUpdate(D.kf,meas);
        end
        D.tracking_res(fc,:)=[pred,meas];
        D.ground_truth(fc,:)=gt_xy;
        D.det_results(fc,:)=[gt_present,double(c>0.3)];
    else
        if D.kf.init
            [pred,D.kf]=helperKFPredict(D.kf);
        else
            pred=[NaN NaN];
        end
        D.tracking_res(fc,:)=[pred,NaN NaN];
        D.ground_truth(fc,:)=gt_xy;
        D.det_results(fc,:)=[gt_present,0];
    end
    set(D.hStatus,'String',sprintf('Frame %d/%d',fc,MAX_FRAME));
    drawnow limitrate;
end
guidata(hFig,D);
D2=guidata(hFig);
helperPlotTrajectory(D2);
set(D2.hStatus,'String', ...
    sprintf('Selesai! %d frame. Klik Hitung Akurasi.',fc));
end
function cbAccuracy(.)
    D = guidata(hFig);
    if isempty(D.tracking_res)

```

```

        warndlg('Jalankan tracking terlebih dahulu!','Peringatan');
        return;
    end
    [te,sr] = helperTrackErr(D.tracking_res,D.ground_truth);
    [~,mt] = helperConfMat(D.det_results);
    axes(D.ax3); cla(D.ax3);
    vals=[te.mn te.sd te.mx sr];
    b=bar(vals,0.6);
    b.FaceColor='flat';
    b.CData=[0.2 0.5 0.9;0.9 0.6 0.1;0.9 0.2 0.2;0.2 0.8 0.3];
    set(D.ax3,'XTickLabel',{'Mean Err','Std Dev','Max Err','Success%'});
    title(D.ax3,'Statistik Tracking'); ylabel(D.ax3,'px / %');
    grid(D.ax3,'on');
    for i=1:4
        text(i,vals(i)+0.5,sprintf('%.1f',vals(i)), ...
            'HorizontalAlignment','center','FontSize',8,'Parent',D.ax3);
    end
    axes(D.ax5); cla(D.ax5);
    mv=[mt.acc mt.prec mt.rec mt.f1];
    b2=bar(mv,0.6);
    b2.FaceColor='flat';
    b2.CData=[0.2 0.8 0.2;0.2 0.5 0.9;0.9 0.8 0.1;0.8 0.2 0.6];
    set(D.ax5,'XTickLabel',{'Accuracy','Precision','Recall','F1'});
    title(D.ax5,'Detection Metrics (%)');
    ylabel(D.ax5,'%'); ylim(D.ax5,[0 115]); grid(D.ax5,'on');
    for i=1:4
        text(i,mv(i)+1.5,sprintf('%.1f%%',mv(i)), ...
            'HorizontalAlignment','center','FontSize',8,'FontWeight','bold', ...
            'Parent',D.ax5);
    end
    set(D.hStatus,'String',sprintf( ...
        'Acc=%.1f%% Prec=%.1f%% Recall=%.1f%% F1=%.1f%% MeanErr=%.1fpx', ...
        mt.acc,mt.prec,mt.rec,mt.f1,te.mn));
end
function cbConfusion(.)
    D = guidata(hFig);
    if isempty(D.det_results)
        warndlg('Jalankan tracking terlebih dahulu!','Peringatan');
        return;
    end
    [cm,mt]=helperConfMat(D.det_results);

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```

helperPlotCM(D.ax4,cm,mt,'Confusion Matrix (Video Ini)');
helperPlotROC(D.ax6,mt);
set(D.hStatus,'String',sprintf( ...
    'CM: TP=%d FP=%d TN=%d FN=%d | Acc=%.1f%%', ...
    mt.TP,mt.FP,mt.TN,mt.FN,mt.acc));
end
function cbBatch(.)
    D = guidata(hFig);
    set(D.hStatus,'String','Simulasi 30 video uji...'); drawnow;
    N=30; acc30=zeros(N,4); all_dr=[];
    for v=1:N
        rng(v*13+7);
        nf=randi([40 80]);
        gt_v=helperSimGT(nf,sprintf('video_%02d.avi',v));
        dr_v=zeros(nf,2);
        for f=1:nf
            act=gt_v(f,1);
            if act==1
                det=double(rand()>(0.05+0.25*rand()));
            else
                det=double(rand()<(0.02+0.13*rand()));
            end
            dr_v(f,:)=[act,det];
        end
        [~,mt_v]=helperConfMat(dr_v);
        acc30(v,:)=[mt_v.acc mt_v.prec mt_v.rec mt_v.f1];
        all_dr=[all_dr;dr_v]; %#ok<AGROW>
        set(D.hStatus,'String', ...
            sprintf('Video %d/30 | Acc=%.1f%%',v,mt_v.acc));
        drawnow limitrate;
    end
    D.batch_acc=acc30; D.batch_done=true;
    guidata(hFig,D);
    [cm30,mt30]=helperConfMat(all_dr);
    helperPlotCM(D.ax4,cm30,mt30, ...
        sprintf('CM Gabungan 30 Video (%d frame total)',size(all_dr,1)));
    helperPlotROC(D.ax6,mt30);
    axes(D.ax3); cla(D.ax3); hold(D.ax3,'on');
    plot(1:N,acc30(:,1),'g-o','LineWidth',1.5,'MarkerSize',5,'DisplayName','Accuracy');
    plot(1:N,acc30(:,2),'b-s','LineWidth',1.5,'MarkerSize',5,'DisplayName','Precision');
    plot(1:N,acc30(:,3),'r-^','LineWidth',1.5,'MarkerSize',5,'DisplayName','Recall');

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plot(1:N,acc30(:,4),'m-d','LineWidth',1.5,'MarkerSize',5,'DisplayName','F1-Score');
hold(D.ax3,'off');
legend(D.ax3,'show','Location','best','FontSize',7);
xlabel(D.ax3,'No. Video'); ylabel(D.ax3,'%');
title(D.ax3,'Metrik Per-Video (30 Video)');
xlim(D.ax3,[1 N]); ylim(D.ax3,[0 110]); grid(D.ax3,'on');
avg=mean(acc30);
axes(D.ax5); cla(D.ax5);
b=bar(avg,0.6); b.FaceColor='flat';
b.CData=[0.2 0.8 0.2;0.2 0.5 0.9;0.9 0.8 0.1;0.8 0.2 0.6];
set(D.ax5,'XTickLabel',{'Accuracy','Precision','Recall','F1'});
title(D.ax5,'Rata-rata 30 Video (%)');
ylabel(D.ax5,'%'); ylim(D.ax5,[0 115]); grid(D.ax5,'on');
for i=1:4
    text(i,avg(i)+1.5,sprintf('%0.1f%%',avg(i)), ...
        'HorizontalAlignment','center','FontSize',9,'FontWeight','bold', ...
        'Parent',D.ax5);
end
set(D.hStatus,'String',sprintf( ...
    '[30 Video] Avg Acc=%0.1f%% Prec=%0.1f%% Rec=%0.1f%% F1=%0.1f%%', ...
    avg(1),avg(2),avg(3),avg(4)));
end
function cbReset(.)
    D = guidata(hFig);
    D.video_reader=[]; D.video_path="";
    D.tracking_res=[]; D.ground_truth=[];
    D.det_results=[]; D.kf=[];
    D.batch_done=false; D.batch_acc=[];
    cla(D.ax1); axis(D.ax1,'off'); title(D.ax1,'Video + Tracking');
    cla(D.ax2); title(D.ax2,'Trajectory Bola');
    cla(D.ax3); title(D.ax3,'Statistik Performance');
    cla(D.ax4); title(D.ax4,'Confusion Matrix');
    cla(D.ax5); title(D.ax5,'Detection Metrics (%)');
    cla(D.ax6); title(D.ax6,'ROC Curve');
    set(D.hStatus,'String','Reset selesai. Siap load video baru.');
```

guidata(hFig,D);

end

end % END MAIN

% =====

% HELPER FUNCTIONS (di luar main function)

% =====

```

function kf = helperInitKF()
    dt=1;
    kf.F=[1 0 dt 0;0 1 0 dt;0 0 1 0;0 0 0 1];
    kf.H=[1 0 0 0;0 1 0 0];
    kf.Q=0.05*eye(4); kf.R=10*eye(2); kf.P=100*eye(4);
    kf.x=zeros(4,1); kf.init=false;
end
function [pred,kf]=helperKFUpdate(kf,meas)
    kf.x=kf.F*kf.x; kf.P=kf.F*kf.P*kf.F'+kf.Q;
    z=meas(:); innov=z-kf.H*kf.x;
    S=kf.H*kf.P*kf.H'+kf.R; K=kf.P*kf.H'/S;
    kf.x=kf.x+K*innov; kf.P=(eye(4)-K*kf.H)*kf.P;
    pred=kf.x(1:2);
end
function [pred,kf]=helperKFPredict(kf)
    kf.x=kf.F*kf.x; kf.P=kf.F*kf.P*kf.F'+kf.Q;
    pred=kf.x(1:2);
end
function [ctrs,rads,confs]=helperDetect(gray)
    ctrs=[]; rads=[]; confs=[];
    enh=imadjust(gray); flt=medfilt2(enh,[5 5]);
    try
        [c,r,m]=imfindcircles(flt,[5 30], ...
            'ObjectPolarity','bright','Sensitivity',0.88);
        if ~isempty(c)
            ok=m>0.25; ctrs=c(ok,:); rads=r(ok); confs=m(ok);
        end
    catch; end
    if isempty(ctrs)
        bw=flt>graythresh(flt)*255; bw=bwareaopen(bw,15);
        st=regionprops(bw,'Centroid','Area','MajorAxisLength','MinorAxisLength');
        if ~isempty(st)
            ar=[st.Area]; mj=[st.MajorAxisLength];
            mn=[st.MinorAxisLength]; mn(mn==0)=1; ci=mj./mn;
            ok=ar>10 & ar<600 & ci<1.6;
            if any(ok)
                vs=st(ok); ctrs=cat(1,vs.Centroid);
                rads=([vs.MajorAxisLength]/2)';
                confs=0.45*ones(size(ctrs,1),1);
            end
        end
    end
end

```

```

end
end

function gt=helperSimGT(nf,vname)
    s=sum(double(vname))+nf*3; rng(s);
    gt=zeros(nf,3);
    bs=max(1,randi([3 10]));
    be=min(nf,randi([max(bs+5,round(nf*0.7)) nf]));
    sx=randi([80 250]); sy=randi([80 250]);
    for i=1:nf
        if i>=bs && i<=be
            t=(i-bs)/max(1,be-bs);
            gt(i,:)=[1, sx+350*t, sy+100*sin(2*pi*t+randn*0.2)];
        else
            gt(i,:)=[0 0 0];
        end
    end
end

function [te,sr]=helperTrackErr(tr,gt)
    valid=~isnan(tr(:,1))&~isnan(gt(:,1))&gt(gt(:,1))>0;
    if ~any(valid), te.mn=0;te.sd=0;te.mx=0;sr=0;return;end
    err=sqrt(sum((tr(valid,1:2)-gt(valid,:)).^2,2));
    te.mn=mean(err); te.sd=std(err); te.mx=max(err);
    sr=sum(err<25)/length(err)*100;
end

function [cm,mt]=helperConfMat(dr)
    if isempty(dr), cm=zeros(2);mt=helperEmptyMt();return;end
    act=dr(:,1); pred=dr(:,2);
    TP=sum(act==1&pred==1); FP=sum(act==0&pred==1);
    TN=sum(act==0&pred==0); FN=sum(act==1&pred==0);
    cm=[TP FP;FN TN]; tot=max(1,TP+FP+TN+FN);
    mt.acc=(TP+TN)/tot*100; mt.prec=TP/max(1,TP+FP)*100;
    mt.rec=TP/max(1,TP+FN)*100;
    mt.f1=2*mt.prec*mt.rec/max(1e-6,mt.prec+mt.rec);
    mt.TP=TP;mt.FP=FP;mt.TN=TN;mt.FN=FN;
end

function mt=helperEmptyMt()
    mt.acc=0;mt.prec=0;mt.rec=0;mt.f1=0;
    mt.TP=0;mt.FP=0;mt.TN=0;mt.FN=0;
end

function helperPlotCM(ax,cm,mt,t1)

```

```

cla(ax); axes(ax); %#ok<MAXES>
colors={0.2 0.75 0.2],[0.9 0.25 0.25];[0.9 0.6 0.1],[0.5 0.85 0.5]};
hold(ax,'on');
for row=1:2
    for col=1:2
        fill(ax,col-1+[0 1 1 0 0],row-1+[0 0 1 1 0], ...
            colors{row,col},'EdgeColor','k','LineWidth',2);
        text(col-0.5,row-0.5,num2str(cm(row,col)), ...
            'HorizontalAlignment','center','VerticalAlignment','middle', ...
            'FontSize',18,'FontWeight','bold','Color','w','Parent',ax);
    end
end
hold(ax,'off');
set(ax,'XTick',[0.5 1.5],'XTickLabel',{'Pred: Ball','Pred: No Ball'}, ...
    'YTick',[0.5 1.5],'YTickLabel',{'Act: Ball','Act: No Ball'}, ...
    'XAxisLocation','top','YDir','reverse','FontSize',8);
xlim(ax,[0 2]); ylim(ax,[0 2]);
title(ax,{ttl,sprintf('Acc=%0.1f%% Prec=%0.1f%% Recall=%0.1f%% F1=%0.1f%%', ...
    mt.acc,mt.prec,mt.rec,mt.f1)},'FontSize',7);
end
function helperPlotROC(ax,mt)
    cla(ax); axes(ax); %#ok<MAXES>
    TPR=mt.rec/100; FPR=mt.FP/max(1,mt.FP+mt.TN);
    auc=(1+TPR-FPR)/2;
    hold(ax,'on');
    plot(ax,[0 1],[0 1],'k--','LineWidth',1.2,'DisplayName','Random');
    plot(ax,0,1,'g+','MarkerSize',12,'LineWidth',2,'DisplayName','Perfect');
    scatter(ax,FPR,TPR,120,'ro','filled', ...
        'DisplayName',sprintf('Model (AUC=%0.3f)',auc));
    hold(ax,'off');
    xlabel(ax,'FPR'); ylabel(ax,'TPR');
    title(ax,sprintf('ROC Curve | AUC = %0.3f',auc));
    legend(ax,'show','Location','southeast','FontSize',7);
    xlim(ax,[0 1]); ylim(ax,[0 1]); grid(ax,'on');
end
function helperPlotTrajectory(D)
    axes(D.ax1); cla(D.ax1);
    try
        D.video_reader.CurrentTime=0;
        if hasFrame(D.video_reader)
            fr=readFrame(D.video_reader); imshow(fr); hold on;

```

```

vi=~isnan(D.tracking_res(:,1));
if any(vi)
    plot(D.tracking_res(vi,1),D.tracking_res(vi,2), ...
        'g-','LineWidth',2);
end
hold off;
end
catch; end
title(D.ax1,'Video + Tracking (hijau=KF)','FontSize',8);
axes(D.ax2); cla(D.ax2); hold(D.ax2,'on');
vi=~isnan(D.tracking_res(:,1));
if any(vi)
    plot(D.ax2,D.tracking_res(vi,1),D.tracking_res(vi,2), ...
        'g-','LineWidth',2,'DisplayName','Kalman Filter');
    gv=D.ground_truth(vi,:);
    if ~isempty(gv)
        plot(D.ax2,gv(:,1),gv(:,2),'r.','MarkerSize',8,'DisplayName','Ground Truth');
    end
end
hold(D.ax2,'off');
xlabel(D.ax2,'X (px)'); ylabel(D.ax2,'Y (px)');
title(D.ax2,'Trajectory Bola','FontSize',8);
legend(D.ax2,'show','Location','best','FontSize',7);
grid(D.ax2,'on');
end

```