

CLAIMS

What is claimed is:

1. A method of laser wavelength control comprising:

making a prediction at first discrete intervals of the position of a prism in a laser system;

receiving at second discrete intervals a measurement of an output wavelength of a master oscillator chamber in the laser system, the second regular intervals being longer than the first regular intervals;

wherein during each first discrete interval:

if the output wavelength measurement has not been received during the first discrete interval then computing in a control computer a control voltage for the prism using the predicted position of the prism,

if the output wavelength measurement has been received during the first discrete interval then updating the predicted position of the prism using the output wavelength measurement and computing in the control computer a control voltage for the prism using the updated predicted position of the prism,

and

outputting the computed control voltage from the control computer to electronics for positioning the prism.

2. The method of claim 1 wherein making the prediction at first discrete intervals of the position of the prism uses a model of the prism's movement.

3. The method of claim 2 wherein the model of the prism's movement is based on the prism's physical movement and disturbances within the laser system.

4. The method of claim 2 wherein the model in its integral form is:

$$x(t+T) = e^{AT}x(t) + \int_0^T e^{A(T-\tau)} Bu(T-\tau) d\tau.$$

5. The method of claim 1 wherein updating the predicted position of the prism using the output wavelength measurement uses the formula:

$$x(k|k) = (I - L_k C_k) x(k|k-1) + L_k y(k).$$

6. A method of laser wavelength control comprising:

making a prediction at first discrete intervals of the position of a prism in a laser system;

receiving at second discrete intervals a measurement of an output wavelength of a master oscillator chamber in the laser system, the second regular intervals being longer than the first regular intervals;

wherein during each first discrete interval:

if the output wavelength measurement has not been received during the first discrete interval then computing in a control computer a control voltage for the prism using the predicted position of the prism,

if the output wavelength measurement has been received during the first discrete interval then

if the laser has fired again since receiving the output wavelength measurement then updating a previous prism position prediction using the output wavelength measurement, making a new of prism position prediction based on the updated previous prism position prediction and computing in the control computer the control voltage for the prism using the new prism position prediction

and

if the laser has not fired again since receiving the output wavelength measurement then updating the predicted position of the prism using the output wavelength measurement and computing in the control computer the control voltage for the prism using the updated prism position prediction

and

outputting the computed control voltage from the control computer to electronics for positioning the prism.

7. The method of claim 6 wherein the first discrete intervals are shorter than the second discrete intervals.

8. The method of claim 6 wherein making the prediction at first discrete intervals of the position of the prism uses a model of the prism's movement.

9. The method of claim 8 wherein the model of the prism's movement is based on the prism's physical movement and disturbances within the laser system.

10. A prism controller method comprising:

predicting at first discrete intervals the position of a prism using a prism movement model

receiving at second discrete intervals a measurement of the output wavelength of a master oscillator chamber controlled by the prism, the second regular intervals being longer than the first regular intervals

wherein during each first discrete interval:

if the output wavelength measurement has not been received during the first discrete interval then computing a control voltage for the prism using the predicted position of the prism,

if the output wavelength measurement has been received during the first discrete interval then updating the predicted position of the prism using the output wavelength measurement and computing a control voltage for the prism using the updated predicted position of the prism,

and

outputting the computed control voltage to electronics for positioning the prism.

11. The method of claim 10 wherein the first discrete intervals are shorter than the second discrete intervals.

12. The method of claim 10 wherein making the prediction at first discrete intervals of the position of the prism uses a model of the prism's movement.

13. The method of claim 12 wherein the model of the prism's movement is based on the prism's physical movement and disturbances within the laser system.

14. The method of claim 12 wherein the model in its integral form is:

$$x(t+T) = e^{AT}x(t) + \int_0^T e^{A\tau} Bu(T-\tau) d\tau.$$

15. The method of claim 10 wherein updating the predicted position of the prism using the output wavelength measurement uses the formula:

$$x(k|k) = (I - L_k C_k) x(k|k-1) + L_k y(k).$$

CLAIMS

What is claimed is:

1. A method of laser wavelength control comprising:

making a prediction at first regular discrete intervals of a position of a prism position in a laser system;

receiving at second regular discrete intervals a measurement of an output wavelength of a master oscillator chamber in the laser system, the second regular discrete intervals being longer than the first regular discrete intervals;

wherein during each first regular discrete interval:

if the output wavelength measurement has not been received during the first regular discrete interval then computing in a control computer a control voltage for the prism using the predicted position of the prism,

if the output wavelength measurement has been received during the first regular discrete interval then updating the predicted position of the prism using the output wavelength measurement and computing in the control computer a control voltage for the prism using the updated predicted position of the prism,

and

outputting the computed control voltage from the control computer to electronics for positioning the prism.

2. The method of claim 1 wherein making the prediction at first regular discrete intervals of the position of the prism uses a model of the prism's movement.

3. The method of claim 2 wherein the model of the prism's movement is based on the prism's physical movement and disturbances within the laser system.

4. The method of claim 2 wherein the model in its integral form is:

$$x(t+T)=e^{AT}x(t)+\int_0^Te^{A\tau}Bu(T-\tau)d\tau,$$

wherein

$x(t+T)$ is the predicted state T -seconds before an initial state $x(t)$;

e^{AT} is a state-transition matrix for a linear system;

B is an input matrix;
u is a value of a transducer signal; and
 τ is a dummy variable.

5. The method of claim 1 wherein updating the predicted position of the prism using the output wavelength measurement uses the formula:

$$x(k|k) = (I - L_k C_k) X(k|k-1) + L_k y(k)$$

wherein

k indexes laser firing events;

I is an identity matrix of n rows by n columns wherein n is a number of elements in a state vector x;

L_k is a gain matrix that captures a tradeoff between trusting new data and believing a previous prediction;

C_k is a mapping from a predicted state to a predicted output;

$x(k|k)$ is an updated prediction given most recent data at index k; and

$x(k|k-1)$ is a non-updated prediction of the predicted state at laser firing index k given data from a previous laser firing event k-1.

6. A method of laser wavelength control comprising:

making a prediction at first regular discrete intervals of a position of a prism in a laser system;
receiving at second regular discrete intervals a measurement of an output wavelength of a master oscillator chamber in the laser system, the second regular discrete intervals being longer than the first regular discrete intervals;

wherein during each first regular discrete interval:

if the output wavelength measurement has not been received during the first regular discrete interval then computing in a control computer a control voltage for the prism using the predicted position of the prism,

if the output wavelength measurement has been received during the first regular discrete interval then

if the laser has fired again since receiving the output wavelength measurement then updating a previous prism position prediction using the output wavelength measurement, making a new prism position prediction based on the updated previous prism position prediction and computing in the control computer the control voltage for the prism using the new prism position prediction

and

if the laser has not fired again since receiving the output wavelength measurement then updating the predicted position of the prism using the output wavelength measurement and computing in the control computer the control voltage for the prism using the updated prism position prediction

and

outputting the computed control voltage from the control computer to electronics for positioning the prism.

7. The method of claim 6 wherein making the prediction at first regular discrete intervals of the position of the prism uses a model of the prism's movement.

8. The method of claim 7 wherein the model of the prism's movement is based on the prism's physical movement and disturbances within the laser system.

9. A prism controller method comprising:

predicting at first regular discrete intervals a position of a prism using a prism movement model;

receiving at second regular discrete intervals a measurement of the output wavelength of a master oscillator chamber controlled by the prism, the second regular discrete intervals being longer than the first regular discrete intervals;

wherein during each first regular discrete interval:

if the output wavelength measurement has not been received during the first regular discrete interval then computing a control voltage for the prism using the predicted position of the prism,

if the output wavelength measurement has been received during the first regular discrete interval then updating the predicted position of the prism using the output wavelength measurement and computing a control voltage for the prism using the updated predicted position of the prism,

and

outputting the computed control voltage to electronics for positioning the prism.

10. The method of claim 9 wherein making the prediction at first regular discrete intervals of the position of the prism uses a model of the prism's movement.

11. The method of claim 10 wherein the model of the prism's movement is based on the prism's physical movement and disturbances within the laser system.

12. The method of claim 10 wherein the model in its integral form is:

$$x(t+T)=e^{AT}x(t)+\int_0^Te^{A\tau}Bu(T-\tau)d\tau$$

wherein

$x(t+T)$ is the predicted state T-seconds before an initial state $x(t)$;

e^{AT} is a state-transition matrix for a linear system;

B is an input matrix;

u is a value of a transducer signal; and

τ is a dummy variable.

13. The method of claim 9 wherein updating the predicted position of the prism using the output wavelength measurement uses the formula:

$$x(k|k)=(I-L_kC_k)X(k|k-1)+L_ky(k)$$

wherein

k indexes laser firing events;

I is an identity matrix of n rows by n columns wherein n is a number of elements in a state vector x;

L_k is a gain matrix that captures a tradeoff between trusting new data and believing a previous prediction;

C_k is a mapping from a predicted state to a predicted output;

$x(k|k)$ is an updated prediction, given most recent data at index k; and

$x(k|k-1)$ is a non-updated prediction of the predicted state at laser firing index k given data from a previous laser firing event k-1.