CLAIMS

What is claimed is:

1. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string; and
a controller to receive a work string trajectory input from a user interface and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the work string trajectory input comprises at least a first work string target position and a first work string target velocity, wherein the first manipulator comprises a first hydraulic actuator, wherein the controller comprises a drive observer that provides an estimated actuator parameter feedback value that is smoothed and substantially zero time lagged based on sensor information received from the actuator, and wherein the controller automatically controls the first manipulator based in part on the estimated actuator parameter feedback value.

2. The well bore servicing equipment of claim 1, wherein the work string trajectory input comprises an ordered sequence of target pairs, wherein each target pair comprises a work string target position and a work string target velocity, and wherein the controller controls the first manipulator to drive the work string to each of the work string target positions at the work string target velocity associated with the work string target position in the ordered sequence.

3. The well bore servicing equipment of claim 1, wherein the first manipulator comprises a first slip bowl to grip the work string and the first hydraulic actuator to exert force on the work string via the first slip bowl to raise and to lower the work string.

4. The well bore servicing equipment of claim 3, wherein the first hydraulic actuator further comprises a hydraulic axial piston pump and wherein the controller controls the flow rate of the hydraulic axial piston pump, whereby the controller controls in part the first manipulator.

5. The well bore servicing equipment of claim 3, wherein the first manipulator further comprises:
a second hydraulic actuator to exert force on the work string via the first slip bowl to raise and to

lower the work string; and a first traveling head that couples the first slip bowl to the first hydraulic actuator and to the second hydraulic actuator.

6. The well bore servicing equipment of claim 1, further including a second manipulator to grip the well bore work string, to raise the work string, and to lower the work string, wherein the controller further automatically controls the second manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input.

7. The well bore servicing equipment of claim 6, further including a collar detector to detect a collar location of the work string.

8. The well bore servicing equipment of claim 7, wherein the controller coordinates control of the first manipulator and the second manipulator to provide substantially continuous movement of the work string in accordance with the work string trajectory input and to avoid one of the first manipulator and the second manipulator gripping the work string at the collar location of the work string, whereby increased operational speed is achieved.

9. The well bore servicing equipment of claim 1, wherein the controller comprises a first manipulator controller to provide a first manipulator force command based on a feedback associated with the first manipulator, based on a model of the first manipulator, and based on a first manipulator command trajectory that is based on the work string trajectory input.

10. The well bore servicing equipment of claim 1, wherein the first manipulator comprises an actuator and wherein the controller comprises a first drive modulator to map a first manipulator force command and a first manipulator velocity command to an actuator control signal.

11. The well bore servicing equipment of claim 10, wherein the first drive modulator maps the first manipulator force command and the first manipulator velocity command to the actuator control signal based on feedback associated with the actuator and based on a model of the actuator.

12. The well bore servicing equipment of claim 1, wherein the drive observer system provides an estimated hydraulic pressure parameter feedback value of a hydraulic chamber of the hydraulic actuator based in part on a model of the hydraulic actuator.

13. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises a hydraulic actuator; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a drive observer that provides an estimated actuator parameter feedback value that is smoothed and substantially zero time lagged based on sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated actuator parameter feedback value, and wherein the drive observer system provides an estimated hydraulic pressure parameter feedback value of a hydraulic chamber of the hydraulic actuator based in part on a model of the hydraulic actuator, and wherein the model is based on an estimated effective piston area, an estimated hydraulic fluid bulk modulus, and an estimated variable hydraulic chamber volume.

14. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises a hydraulic actuator; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a drive observer that provides an estimated flow disturbance value that is smoothed and based on sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated flow disturbance value.

15. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string; and
a controller to receive a work string trajectory input from a user interface and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the work string trajectory comprises at least a first work string target position and a first work string target velocity, wherein the first manipulator comprises an actuator, wherein the controller comprises a manipulator observer that provides an estimated actuator position feedback value that is smoothed and substantially zero time lagged based on actuator position sensor information received from the actuator, and wherein the controller automatically controls the first manipulator based in part on the estimated actuator position feedback value.

16. The well bore servicing equipment of claim 15, wherein the manipulator observer further provides an estimated actuator velocity feedback value that is smoothed and substantially zero time lagged based on actuator velocity sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated actuator velocity feedback value.

17. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises an actuator and a force coupling component to couple force output by the actuator to the work string; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a manipulator observer that provides an estimated actuator position feedback value that is smoothed and substantially zero time lagged based on actuator position sensor information received from the actuator, wherein the manipulator observer provides the estimated actuator position feedback value based in part on a model of the force coupling component, and wherein the controller automatically controls the first manipulator based in part on the estimated actuator position feedback value.

18. The well bore servicing equipment of claim 17, wherein the model is based on an estimated mass of the force coupling component, an estimated weight of the force coupling component, and an estimated damping factor of the force coupling component.

19. The well bore servicing equipment of claim 18, wherein the model is further based on an estimated friction of the force coupling component moving within a restraint mechanism.

20. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises an actuator; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a manipulator observer that provides an estimated disturbance force feedback value that is smoothed and based on actuator position sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated disturbance force feedback value.

21. A pressure observer, comprising:

a first proportional-integral (PI) controller portion operable to determine a first pressure error and to generate a first corrective signal based on the first pressure error; a first feed-forward portion operable to determine a first flow rate based on a first velocity and a first gain;

a first integrator operable to integrate the sum of the first corrective signal and the first flow rate; and

a second gain operable to amplify an output of the first integrator by a first model gain and to produce a first pressure estimate.

22. The pressure observer according to claim 21, wherein the first proportional-integral controller portion is further operable to determine a first flow disturbance signal based on the first pressure error.

23. The pressure observer according to claim 21 , wherein the first pressure error is determined as the difference of a first sensed pressure and the first pressure estimate.

24. The pressure observer according to claim 21, wherein the first gain is proportional to the difference of an area of a piston of a hydraulic actuator and an cross-section area of a rod of the hydraulic actuator.

25. The pressure observer according to claim 21, wherein the first model gain is proportional to a bulk modulus of a hydraulic fluid and is inversely proportional to a volume comprising a rod side chamber of a hydraulic actuator, wherein the volume of the rod side chamber changes as a rod of the hydraulic actuator moves.

26. The pressure observer according to claim 21, further comprising:

a second proportional-integral (PI) controller portion operable to determine a second pressure error and to generate a second corrective signal based on the second pressure error;

a second feed-forward portion operable to determine a second flow rate based on a second velocity and a second gain;

a second integrator operable to integrate the sum of the second corrective signal and the second flow rate; and

a second gain operable to amplify an output of the second integrator by a second model gain and to produce a second pressure estimate.

27. A control system for controlling movement of a work string in a well bore, comprising: a controller comprising a processor, a memory, and a pressure observer component, wherein the pressure observer component comprising:

a first proportional-integral (PI) controller portion operable to determine a first pressure error and to generate a first corrective signal based on the first pressure error;

a first feed-forward portion operable to determine a first flow rate based on a velocity of a first hydraulic actuator and a first gain;

a first integrator operable to integrate the sum of the first corrective signal and the first flow rate; and a second gain operable to amplify an output of the first integrator by a first model gain and to produce a first pressure estimate, wherein the controller commands the first hydraulic actuator to move the work string based at least in part on the first pressure estimate.

28. The control system according to claim 27, wherein the first proportional-integral controller portion is further operable to determine a first flow disturbance signal based on the

first pressure error , and wherein the controller commands the first hydraulic actuator to move the work string further based on the first flow disturbance signal.

29. The pressure observer according to claim 27, wherein the first pressure error is determined as the difference of a first sensed pressure and the first pressure estimate.

30. The pressure observer according to claim 27, wherein the first gain is proportional to the difference of an area of a piston of a hydraulic actuator and an cross-section area of a rod of the hydraulic actuator.

31. The pressure observer according to claim 27, wherein the first model gain is proportional to a bulk modulus of a hydraulic fluid and is inversely proportional to a volume comprising a rod side chamber of a hydraulic actuator, wherein the volume of the rod side chamber changes as a rod of the hydraulic actuator moves.

32. The pressure observer according to claim 27, further comprising:

a second proportional-integral (PI) controller portion operable to determine a second pressure error and to generate a second corrective signal based on the second pressure error;

a second feed-forward portion operable to determine a second flow rate based on a second velocity and a second gain;

a second integrator operable to integrate the sum of the second corrective signal and the second flow rate; and

a second gain operable to amplify an output of the second integrator by a second model gain and to produce a second pressure estimate.

33. A method of servicing a wellbore with a work string, comprising:

receiving a work string trajectory input from a user interface, wherein the work string trajectory comprises at least a first work string target position and a first work string target velocity;

determining a first pressure error and generating a first corrective signal based on the first pressure error;

determining a first flow rate based on a velocity of a first hydraulic actuator and a first gain;

integrating the sum of the first corrective signal and the first flow rate to determine a first integrated value;

determining a first pressure estimate based on amplifying the first integrated value by a first model gain;

determining a first hydraulic actuator control command based on the first pressure estimate and the work string trajectory input moving the workstring within the wellbore responsive to the first hydraulic actuator control command.

34. The method according to claim 33, further comprising determining a first flow disturbance signal based on the first pressure error, wherein determining the first hydraulic actuator control command is further based on the first flow disturbance signal.

35. The method according to claim 33, wherein the first pressure error is determined as the difference of a first sensed pressure and the first pressure estimate.

36. The method according to claim 33, wherein the first gain is proportional to the difference of an area of a piston of the first hydraulic actuator and a cross-section area of a rod of the first hydraulic actuator.

37. The method according to claim 33, wherein the first model gain is proportional to a bulk modulus of a hydraulic fluid and is inversely proportional to a volume comprising a rod side chamber of the first hydraulic actuator, wherein the volume of the rod side chamber changes as a rod of the first hydraulic actuator moves.

38. The method according to claim 33, further comprising: determining a second pressure error and to generate a second corrective signal based on the second pressure error; determining a second flow rate based on a velocity of a second hydraulic actuator and a second gain; integrating the sum of the second corrective signal and the second flow rate to determine a second integrated value; determining a second pressure estimate based on amplifying the second integrated value by a second model gain and to produce a second pressure estimate; and determining a second hydraulic actuator control command based on the second pressure estimate and the work string trajectory input.

39. The method according to claim 38, further comprising determining a second flow disturbance signal based on the second pressure error, wherein determining the second hydraulic control command is further based on the second flow disturbance signal.

40. The method according to claim 38, wherein the second pressure error is determined as the difference of a second sensed pressure and a second pressure estimate.

41. A manipulator position and velocity observer, comprising:

a proportional-integral-derivative (PID) controller portion operable to determine a manipulator position error and a manipulator velocity error and to generate a corrective signal based on the manipulator position error and on the manipulator velocity error;

a first gain operable to amplify an indication of manipulator velocity by a manipulator damper gain to generate a damper force signal;

a force summation portion that is operable to determine a summed force term based on the corrective signal, based on the damper force signal, based on a force command, and based on a manipulator weight term;

a second gain operable to amplify the summed force term by an inverse manipulator gain and to generate a manipulator acceleration term;

a first integrator operable to integrate the manipulator acceleration term to generate a manipulator velocity term and to output an estimate of manipulator velocity; and

a second integrator operable to integrate the manipulator velocity term to generate a manipulator position term and to output an estimate of manipulator position.

42. The manipulator position and velocity observer according to claim 41, wherein the proportional-integral-derivative controller portion is further operable to produce a manipulator force disturbance term based on the manipulator position error and on the manipulator velocity error.

43. The manipulator position and velocity observer according to claim 41, wherein the manipulator position error is determined as the difference of a sensed manipulator position and the estimate of manipulator position.

44. The manipulator position and velocity observer according to claim 41, wherein the manipulator velocity error is determined as the difference of a sensed manipulator velocity and the estimate of manipulator velocity.

45. The manipulator position and velocity observer according to claim 41, further comprising a third gain operable to amplify the indication of manipulator velocity by a friction gain to determine a friction force signal, wherein the summed force term is further based on the friction force signal.

46. The manipulator position and velocity observer according to claim 41, wherein the manipulator weight term is a constant value configured in the manipulator position and velocity observer.

47. A control system for controlling movement of a work string in a well bore, comprising:

a controller comprising a processor, a memory, and a manipulator velocity and position observer component comprising:

a proportional-integral-derivative (PID) controller portion operable to determine a manipulator position error and a manipulator velocity error and to generate a corrective signal based on the manipulator position error and on the manipulator velocity error;

a first gain operable to amplify an indication of manipulator velocity by a manipulator damper gain to generate a damper force signal;

a force summation portion that is operable to determine a summed force term based on the corrective signal, based on the damper force signal, based on a force command, and based on a manipulator weight term;

a second gain operable to amplify the summed force term by an inverse manipulator gain and to generate a manipulator acceleration term;

a first integrator operable to integrate the manipulator acceleration term to generate a manipulator velocity term and to output an estimate of manipulator velocity; and

a second integrator operable to integrate the manipulator velocity term to generate a manipulator position term and to output an estimate of manipulator position,

wherein the controller receives a work string trajectory input from a user interface, the trajectory input comprising at least a first work string target position and a first work string target velocity, and commands a first manipulator to move the work string based at least in part on the

estimate of manipulator velocity, the estimate of manipulator position, and the work string trajectory input.

48. The control system according to claim 47, wherein the proportional-integral-derivative controller portion is further operable to produce a manipulator force disturbance term based on the manipulator position error and on the manipulator velocity error.

49. The control system according to claim 47, wherein the manipulator position error is determined as the difference of a sensed manipulator position and the estimate of manipulator position.

50. The control system according to claim 47, wherein the manipulator velocity error is determined as the difference of a sensed manipulator velocity and the estimate of manipulator velocity.

51. The control system according to claim 47, further comprising a third gain operable to amplify the indication of manipulator velocity by a friction gain to determine a friction force signal, wherein the summed force term is further based on the friction force signal.

52. The control system according to claim 47, wherein the manipulator weight term is a constant value configured in the manipulator position and velocity observer.

53. A method of servicing a well bore with a work string, comprising:

determining a manipulator position error and a manipulator velocity error; generating a corrective signal based on the manipulator position error and on the manipulator velocity error;

amplifying an indication of manipulator velocity by a manipulator damper gain to generate a damper force signal;

determining a summed force term based on the corrective signal, based on the damper force signal;

amplifying the summed force term by an inverse manipulator gain to generate a manipulator acceleration term;

integrating the manipulator acceleration term to generate a manipulator velocity term and to output an estimate of manipulator velocity;

integrating the manipulator velocity term to generate a manipulator position term and to output an estimate of manipulator position;

receiving a work string trajectory input from a user interface, the trajectory input comprising at least a first work string target position and a first work string target velocity; and

commanding a first manipulator to move the work string based at least in part on the estimate of manipulator velocity, the estimate of manipulator position, and the work string trajectory input.

54. The method according to claim 53, further comprising determining a manipulator force disturbance term based on the manipulator position error and on the manipulator velocity error, wherein commanding the first manipulator to move the work string is further based on the manipulator force disturbance term.

55. The method according to claim 53, wherein the manipulator position error is determined as the difference of a sensed manipulator position and the estimate of manipulator position.

56. The method according to claim 53, wherein the manipulator velocity error is determined as the difference of a sensed manipulator velocity and the estimate of manipulator velocity.

57. The method according to claim 53, further comprising amplifying the indication of manipulator velocity by a friction gain to determine a friction force signal, wherein the summed force term is further based on the friction force signal.

58. The method according to claim 53, wherein the manipulator weight term is a constant value.

59. The method according to any claim 53, wherein determining the summed force term is further based on a force command.

60. The method according to claim 53, wherein determining the summed force term is further based on a manipulator weight term.

61. A method of servicing a well bore with a work string, comprising:

placing the work string in a well bore;

receiving a work string trajectory input from a user interface, wherein the work string trajectory input comprises at least a first work string target position and a first work string target velocity;

determining a simulated force feedback of the work string on a first manipulator, wherein determining the simulated force feedback of the work string on the first manipulator is based at least in part on one of a sensed and an estimated first manipulator position and on one of a sensed and an estimated first manipulator velocity, and wherein determining the simulated force feedback of the work string on the first manipulator is further based one of a sensed and an estimated first slip bowl position, wherein the first slip bowl is coupled to the first manipulator;

determining an estimated work string velocity based at least on the simulated force feedback of the work string on the first manipulator and on the work string trajectory input;

determining an estimated work string position based at least on the simulated force feedback of the work string on the first manipulator and on the work string trajectory input;

determining a first manipulator position command and a first manipulator velocity command based on the estimated work string position and the estimated work string velocity; and

automatically controlling the first manipulator based at least on the first manipulator position command and the first manipulator velocity command, wherein the first manipulator moves the work string in the well bore.

62. The method of claim 61, further comprising:

determining a simulated force feedback of the work string on a second manipulator;

determining the estimated work string velocity further based on the simulated force feedback of the work string on the second manipulator;

determining the estimated work string position further based on the simulated force feedback of the work string on the second manipulator;

determining a first feed forward work string load command, a second manipulator position command, a second manipulator velocity command, and a second feed forward work string load command based on the estimated work string position and the estimated work string velocity;

further automatically controlling the first manipulator based on the first feed forward work string load command; and

automatically controlling the second manipulator based at least on the second manipulator position command, the second manipulator velocity command, and the second feed forward work string load command, wherein the second manipulator moves the work string in the well bore.

63. The method of claim 61, wherein determining the simulated force feedback of the work string on the first manipulator is further based on a commanded first slip bowl position.

64. The method of claim 61, wherein determining the simulated force feedback of the work string on the first manipulator is further based at least in part on a commanded first manipulator position and commanded first manipulator velocity.

65. A control system for controlling movement of a work string in a well bore, comprising: a controller comprising a processor, a memory, and an application stored in the memory, wherein the application, when executed by the processor receives a work string trajectory input from a user interface, wherein the work string trajectory input comprises at least a first work string target position and a first work string target velocity; determines a simulated force feedback of the work string on a first manipulator; determines an estimated work string velocity based at least on the simulated force feedback of the work string on the first manipulator and on the work string trajectory input; determines an estimated work string position based at least on the simulated force feedback of the work string on the first manipulator and on the work string trajectory input;

determines a first manipulator position command and a first manipulator velocity command based on the estimated work string position and the estimated work string velocity; and

controls the first manipulator based at least on the first manipulator position command and the first manipulator velocity command, wherein the first manipulator moves the work string in the well bore;

wherein the application further determines a simulated force feedback of the work string on a second manipulator; determines the estimated work string velocity further based on the simulated, force feedback of the work string on the second manipulator;

determines the estimated work string position further based on the simulated force feedback of the work string on the second manipulator;

determines the first feed forward work string load command, a second manipulator position command, a second manipulator velocity command, and a second feed forward work string load command based on the estimated work string position and the estimated work string velocity;

controls the first manipulator based on the first feed, forward work string load command; and

controls the second manipulator based at least on the second manipulator position command, the second manipulator velocity command, and the second feed forward work string load command, wherein the second manipulator moves the work string in the well bore.

66. The control system of claim 65, wherein determining the simulated force feedback of the work string on the first manipulator is based at least in part on one of a sensed and an

estimated first manipulator position and on one of a sensed and an estimated first manipulator velocity.

67. The control system of claim 66, wherein determining the simulated force feedback of the work string on the first manipulator is further based on one of a sensed and an estimated first slip bowl position, wherein the first slip bowl is coupled to the first manipulator.

68. The control system of claim 67, wherein determining the simulated force feedback of the work string on the first manipulator is based further on the first slip bowl position.

69. The control system of claim 66, wherein determining the simulated force feedback of the work string on the first manipulator is further based at least in part on a commanded first manipulator position and a commanded first manipulator velocity.

70. A system for servicing a well bore with a work string, comprising:

a first manipulator for gripping and moving the work string in the well bore; a first manipulator drive for providing power to the first manipulator;

a controller coupled to the first manipulator drive comprising a processor, a memory, and

an application stored in the memory, wherein the application, when executed by the processor

receives a work string trajectory input from a user interface, wherein the work string trajectory input comprises at least a first work string target position and a first work string target velocity;

determines a simulated force feedback of the work string on the first manipulator, wherein determining simulated force feedback of the work string on the first manipulator is based at least in part on one of a sensed and an estimated first manipulator position and on one of a sensed and an estimated first manipulator velocity; and wherein determining the simulated force feedback of the work string on the first manipulator is further based on one of a sensed and an estimated first manipulator first slip bowl position, wherein the first slip bowl is coupled to the first manipulator;

determines an estimated work string velocity based at least on the simulated force feedback of the work string on the first manipulator and on the work string trajectory input;

determines an estimated work string position based at least on the simulated force feedback of the work string on the first manipulator and on the work string trajectory input;

determines a first manipulator position command and a first manipulator velocity command based on the estimated work string position and the estimated work string velocity; and

controls the first manipulator drive based at least on the first manipulator position command and the first manipulator velocity command, wherein the first manipulator moves the work string in the well bore.

71. The system of claim 70, further comprising a second manipulator for gripping and moving the work string in the well bore, a second manipulator drive for providing power to the second manipulator, wherein the controller is coupled to the second manipulator drive, and

wherein the application further determines a simulated force feedback of the work string on the second manipulator; determines the estimated work string velocity further based on the simulated force feedback of the work string on the second manipulator;

determines the estimated work string position further based on the simulated force feedback of the work string on the second manipulator;

determines a first feed forward work string load command, a second manipulator position command, a second manipulator velocity command, and a second feed

forward work string load command based on the estimated work string position and the estimated work string velocity;

controls the first manipulator based on the first feed forward work string load command; and

controls the second manipulator drive based at least on the second manipulator position command, the second manipulator velocity command, and the second feed forward work string load command, wherein the second manipulator moves the work string in the well bore.

72. The system of claim 70, wherein determining the simulated force feedback of the work string on the first manipulator is further based on a commanded first slip bowl position.

73. The system of claim 70, wherein determining the simulated force feedback of the work string on the first manipulator is further based at least in part on a commanded first manipulator position and a commanded first manipulator velocity.

74. The system of claim 70, wherein the first manipulator drive provides hydraulic power to the first manipulator.

75. The system of claim 70, wherein the first manipulator drive provides electrical power to the first manipulator.

76. A method of servicing a well bore with a work string, comprising:

receiving a control mode input from a user interface, wherein the control mode input identifies a work string control mode of operation;

receiving a work string trajectory input from the user interface, wherein the work string trajectory comprises at least a first work string target position and a first work string target velocity; and

automatically controlling a plurality of manipulators to drive the work string to substantially match the work string trajectory input according to the work string control mode of operation.

77. The method of claim 76, wherein the control mode input identifies a distributed load sequential mode, where a first manipulator and a second manipulator are controlled to concurrently grip the work string and to apply force to the work string in the same direction at the same time.

78. The method of claim 76, wherein the control mode input identifies a high speed sequential mode, where a first manipulator trades off gripping the work string with a second manipulator and wherein the work string is moved by the first manipulator and the second manipulator in a sequence of start and stop actions.

79. The method of claim 76, wherein the control mode input identifies a high speed continuous mode, where a first manipulator trades off gripping the work string with a second manipulator and wherein the work string is moved by the first manipulator and second manipulator with a substantially constant velocity.

80. The method of claim 76, wherein the control mode input identifies a high speed constrained mode, where a first manipulator trades off gripping the work string with a second manipulator to achieve a maximum hand-off speed between the first manipulator and the second manipulator.

81. The method of claim 76, further comprising receiving a pipe collar indication, wherein controlling the plurality of manipulators is based further on the pipe collar indication.

82. A control system for controlling movement of a work string in a well bore, comprising:

a controller comprising a processor, a memory, and an application stored in the memory, wherein the application when executed by the processor

receives a control mode input from a user interface, wherein the control mode input identifies a work string control mode of operation;

receives a work string trajectory input from the user interface, wherein the work string trajectory comprises at least a first work string target position and a first work string target velocity; and

controls a plurality of manipulators to drive the work string to substantially match the work string trajectory input according to the work string control mode of operation.

83. The control system of claim 82, wherein the control mode input identifies a distributed load sequential mode, where a first manipulator and a second manipulator are controlled to concurrently grip the work string and to apply force to the work string in the same direction at the same time.

84. The control system of claim 82, wherein the control mode input identifies a high speed sequential mode, where a first manipulator trades off gripping the work string with a second manipulator and wherein the work string is moved by the first manipulator and the second manipulator in a sequence of start and stop actions.

85. The control system of claim 82, wherein the control mode input identifies a high speed continuous mode, where a first manipulator trades off gripping the work string with a second manipulator and wherein the work string is moved by the first manipulator and second manipulator with a substantially constant velocity.

86. The control system of claim 82, wherein the control mode input identifies a high speed constrained mode, where a first manipulator trades off gripping the work string with a second manipulator to achieve a maximum hand-off speed between the first manipulator and the second manipulator.

87. The control system of claim 82, wherein the application further receives a pipe collar indication and controls the plurality of manipulators based further on the pipe collar indication.

88. A system for servicing a well bore with a work string, comprising:

a first manipulator for gripping and moving the work string in the well bore; a first manipulator drive for providing power to the first manipulator;

a second manipulator for gripping and moving the work string in the well bore; a second manipulator drive for providing power to the second manipulator;

a controller comprising a processor, a memory, and an application stored in the memory, wherein the controller is coupled to the first manipulator drive and to the second manipulator drive, wherein the application when executed by the processor receives a control mode input from a user interface, wherein the control mode input identifies a work string control mode of operation;

receives a work string trajectory input from the user interface, wherein the work string trajectory comprises at least a first work string target position and a first work string target velocity; and

controls the first manipulator drive and the second manipulator drive to drive the work string to substantially match the work string trajectory input according to the work string control mode of operation.

89. The system of claim 88, wherein the control mode input identifies a distributed load sequential mode, where a first manipulator and a second manipulator are controlled to concurrently grip the work string and to apply force to the work string in the same direction at the same time.

90. The system of claim 88, wherein the control mode input identifies a high speed sequential mode, where a first manipulator trades off gripping the work string with a second manipulator and wherein the work string is moved by the first manipulator and the second manipulator in a sequence of start and stop actions.

91. The system of claim 88, wherein the control mode input identifies a high speed continuous mode, where a first manipulator trades off gripping the work string with a second manipulator and wherein the work string is moved by the first manipulator and second manipulator with a substantially constant velocity.

92. The system of claim 88, wherein the control mode input identifies a high speed constrained mode, where a first manipulator trades off gripping the work string with a second manipulator to achieve a maximum hand-off speed between the first manipulator and the second manipulator.

93. The system of claim 88, wherein the application further receives a pipe collar indication and controls the plurality of manipulators based further on the pipe collar indication.

94. The system of claim 88, wherein the first manipulator drive provides hydraulic power to the first manipulator and the second manipulator drive provides hydraulic power to the second manipulator.

95. The system of claim 88, wherein the first manipulator drive provides electric power to the first manipulator and the second manipulator drive provides electric power to the second manipulator.

CLAIMS

What is claimed is:

1. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string; and
a controller to receive a work string trajectory input from a user interface and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the work string trajectory input comprises at least a first work string target position and a first work string target velocity, wherein the first manipulator comprises a first hydraulic actuator, wherein the controller comprises a drive observer that provides an estimated actuator parameter feedback value that is smoothed and substantially zero time lagged based on sensor information received from the actuator, and wherein the controller automatically controls the first manipulator based in part on the estimated actuator parameter feedback value.

2. The well bore servicing equipment of claim 1, wherein the work string trajectory input comprises an ordered sequence of target pairs, wherein each target pair comprises a work string target position and a work string target velocity, and wherein the controller controls the first manipulator to drive the work string to each of the work string target positions at the work string target velocity associated with the work string target position in the ordered sequence.

3. The well bore servicing equipment of claim 1, wherein the first manipulator comprises a first slip bowl to grip the work string and the first hydraulic actuator to exert force on the work string via the first slip bowl to raise and to lower the work string.

4. The well bore servicing equipment of claim 3, wherein the first hydraulic actuator further comprises a hydraulic axial piston pump and wherein the controller controls the flow rate of the hydraulic axial piston pump, whereby the controller controls in part the first manipulator.

5. The well bore servicing equipment of claim 3, wherein the first manipulator further comprises:
a second hydraulic actuator to exert force on the work string via the first slip bowl to raise and to

lower the work string; and a first traveling head that couples the first slip bowl to the first hydraulic actuator and to the second hydraulic actuator.

6. The well bore servicing equipment of claim 1, further including a second manipulator to grip the well bore work string, to raise the work string, and to lower the work string, wherein the controller further automatically controls the second manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input.

7. The well bore servicing equipment of claim 6, further including a collar detector to detect a collar location of the work string.

8. The well bore servicing equipment of claim 7, wherein the controller coordinates control of the first manipulator and the second manipulator to provide substantially continuous movement of the work string in accordance with the work string trajectory input and to avoid one of the first manipulator and the second manipulator gripping the work string at the collar location of the work string, whereby increased operational speed is achieved.

9. The well bore servicing equipment of claim 1, wherein the controller comprises a first manipulator controller to provide a first manipulator force command based on a feedback associated with the first manipulator, based on a model of the first manipulator, and based on a first manipulator command trajectory that is based on the work string trajectory input.

10. The well bore servicing equipment of claim 1, wherein the first manipulator comprises an actuator and wherein the controller comprises a first drive modulator to map a first manipulator force command and a first manipulator velocity command to an actuator control signal.

11. The well bore servicing equipment of claim 10, wherein the first drive modulator maps the first manipulator force command and the first manipulator velocity command to the actuator control signal based on feedback associated with the actuator and based on a model of the actuator.

12. The well bore servicing equipment of claim 1, wherein the drive observer system provides an estimated hydraulic pressure parameter feedback value of a hydraulic chamber of the hydraulic actuator based in part on a model of the hydraulic actuator.

13. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises a hydraulic actuator; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a drive observer that provides an estimated actuator parameter feedback value that is smoothed and substantially zero time lagged based on sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated actuator parameter feedback value, and wherein the drive observer system provides an estimated hydraulic pressure parameter feedback value of a hydraulic chamber of the hydraulic actuator based in part on a model of the hydraulic actuator, and wherein the model is based on an estimated effective piston area, an estimated hydraulic fluid bulk modulus, and an estimated variable hydraulic chamber volume.

14. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises a hydraulic actuator; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a drive observer that provides an estimated flow disturbance value that is smoothed and based on sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated flow disturbance value.

15. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string; and
a controller to receive a work string trajectory input from a user interface and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the work string trajectory comprises at least a first work string target position and a first work string target velocity, wherein the first manipulator comprises an actuator, wherein the controller comprises a manipulator observer that provides an estimated actuator position feedback value that is smoothed and substantially zero time lagged based on actuator position sensor information received from the actuator, and wherein the controller automatically controls the first manipulator based in part on the estimated actuator position feedback value.

16. The well bore servicing equipment of claim 15, wherein the manipulator observer further provides an estimated actuator velocity feedback value that is smoothed and substantially zero time lagged based on actuator velocity sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated actuator velocity feedback value.

17. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises an actuator and a force coupling component to couple force output by the actuator to the work string; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a manipulator observer that provides an estimated actuator position feedback value that is smoothed and substantially zero time lagged based on actuator position sensor information received from the actuator, wherein the manipulator observer provides the estimated actuator position feedback value based in part on a model of the force coupling component, and wherein the controller automatically controls the first manipulator based in part on the estimated actuator position feedback value.

18. The well bore servicing equipment of claim 17, wherein the model is based on an estimated mass of the force coupling component, an estimated weight of the force coupling component, and an estimated damping factor of the force coupling component.

19. The well bore servicing equipment of claim 18, wherein the model is further based on an estimated friction of the force coupling component moving within a restraint mechanism.

20. Well bore servicing equipment, comprising:
a first manipulator operable to grip a well bore work string, to raise the work string, and to lower the work string, wherein the first manipulator comprises an actuator; and
a controller to receive a work string trajectory input and to automatically control the first manipulator to raise and to lower the work string substantially in conformance with the work string trajectory input, wherein the controller comprises a manipulator observer that provides an estimated disturbance force feedback value that is smoothed and based on actuator position sensor information received from the actuator, wherein the controller automatically controls the first manipulator based in part on the estimated disturbance force feedback value.