CLAIMS

What is claimed is:

1. A method for force measurement using a mobile device, the method comprising:
causing a vibration motor of the mobile device to vibrate;
acquiring, using an inertial measurement unit (IMU) of the mobile device, IMU data indicative of vibration damping that is caused by a user applying a force on the mobile device; and
determining the applied force based on a force model and the IMU data.

2. The method of claim 1, wherein determining the applied force comprises processing the IMU data based on at least one of filtering, a filter bank, averaging, standard deviation, wavelet decomposition, spectral analysis, or empirical mode decomposition (EMD).

3. The method of claim 2, wherein:
the IMU data comprises multi-axis accelerometer data and multi-axis gyroscope data,
each axis of the multi-axis accelerometer data and the multi-axis gyroscope data comprises a signal,
determining the applied force comprises for each axis of the multi-axis accelerometer data and the multi-axis gyroscope data, decomposing a signal of the axis into a plurality of intrinsic mode functions (IMFs) representing different frequency components of the signal, and
the applied force is determined based on at least a portion of the IMFs that correspond to various axes of the multi-axis accelerometer data and the multi-axis gyroscope data.

4. The method of claim 3, wherein determining the applied force further comprises:
for each axis of the multi-axis accelerometer data and the multi-axis gyroscope data,

identifying, from the plurality of IMFs of the signal of the axis, a first IMF that corresponds to a highest frequency;

identifying an upper envelope of the first IMF of the axis; and

inputting into the force model the upper envelopes of the first IMFs that respectively correspond to all axes of the multi-axis accelerometer data and the multi-axis gyroscope data.

5. The method of claim 1, further comprising at least one of:

providing a visual guide to be presented on a display of the mobile device, wherein the visual guide comprises at least one of:

a force plot that illustrates the applied force in substantially real time,

a force guide line overlaid with the applied force, or

indicia to guide the user in applying the force by gripping the mobile device using a hand of the user.

6. The method of claim 1, further comprising:

assessing a condition of the user based on the applied force; and

generating a notification based on a result of the assessment.

7. The method of claim 1, further comprising:

obtaining, from a model library, the force model based on a type of the mobile device, wherein the type of the mobile device is associated with at least one of a configuration of the IMU or a configuration of the vibration motor.

8. The method of claim 1, wherein the force model comprises at least one of:

a machine learning algorithm trained to correlate (1) the IMU data measured by the mobile device that is indicative of the vibration damping of the mobile device with (2) the force that is applied to the mobile device and cause the vibration damping, or

a multivariate linear regression model trained based on training data acquired using a force sensor and a training mobile device of a same type as the mobile device.

9. The method of claim 1, wherein:

the force model is configured to generate results on a continuous scale, and

the method further comprises: assigning the applied force to one of multiple categories.

10. A mobile device, comprising: a vibration motor, an inertial motion unit (IMU), a processor, and non-transitory computer-readable memory that stores instructions that, when executed by the processor, cause the processor to perform operations including:

causing the vibration motor to vibrate;

acquiring, using the IMU of the mobile device, IMU data indicative of vibration damping that is caused by a user applying a force on the mobile device; and

determining the applied force based on a force model and the IMU data.

11. The mobile device of claim 10, wherein the force model comprises a machine learning algorithm trained to correlate (1) the IMU data measured by the mobile device that is indicative of the vibration damping of the mobile device with (2) the force that is applied to the mobile device and cause the vibration damping.

12. The mobile device of claim 10, wherein the IMU comprises an accelerometer and a gyroscope, and the IMU data comprises multi-axis accelerometer data and multi-axis gyroscope data.

13. One or more non-transitory computer-readable media storing instructions that, when executed by one or more processors of a mobile device, cause the mobile device to perform operations including:

causing a vibration motor of the mobile device to vibrate;

acquiring, using an inertial measurement unit (IMU) of the mobile device, IMU data indicative of vibration damping that is caused by a user applying a force on the mobile device; and

determining the applied force based on a force model and the IMU data.

14. The one or more non-transitory computer-readable media of claim 13, wherein the operations further include:

obtaining, from a model library, the force model based on a type of the mobile device, wherein the type of the mobile device is associated with at least one of a configuration of the IMU or a configuration of the vibration motor.

15. The one or more non-transitory computer-readable media of claim 13, wherein the force model comprises a machine learning algorithm trained to correlate (1) the IMU data acquired from concurrent measurements by an accelerometer and a gyroscope of the mobile device and indicative of the vibration damping of the mobile device with (2) the force that is applied to the mobile device and cause the vibration damping.