CLAIMS

What is claimed is:

1. A method for measuring blood pressure 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's body part applying a force on a camera of the mobile device;

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

capturing, using the camera of the mobile device, photoplethysmography (PPG) data of a set of blood vessels in the body part concurrently with the application of the force; and

determining a blood pressure of the user using an oscillometric technique based on the PPG data and the applied force.

2. The method of claim 1, wherein determining the applied force from the IMU data 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 from the IMU data 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 from the IMU data 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; and

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, wherein the PPG data relates to a volume of blood flow within the set of blood vessels that varies with an amplitude of the applied force, and/or records intensity in a red channel of the camera.

6. The method of claim 1, wherein the mobile device is placed on a supporting surface when the user applies the force, the method further comprising:

performing a surface calibration by characterizing a material of the supporting surface; and

determining the applied force based further on the surface calibration.

7. The method of claim 1, further comprising:

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 placing a surface of the body part onto the camera.

8. The method of claim 1, further comprising:

measuring an area of a surface of the body part, wherein the force is applied by pressing the surface of the body part against the camera; and

determining an applied pressure based on the applied force and the area,

wherein determining the blood pressure comprises:

generating an oscillogram based on the PPG data and the applied pressure; and

deriving the blood pressure from the oscillogram.

9. The method of claim 1, wherein:

the body part of the user is a tip portion of a finger, and

the set of blood vessels includes at least one blood vessel in a transverse palmar arch branch of a digital artery in the tip portion of the finger.

10. 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, a configuration of the vibration motor, or a configuration of the camera.

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

cause the vibration motor to vibrate;

acquire, by the IMU of the mobile device, IMU data indicative of vibration damping that is caused by a user's body part applying a force on the camera;

determine the applied force based on a force model and the IMU data;

capture, by the camera of the mobile device, photoplethysmography (PPG) data of a set of blood vessels in the body part concurrently with the application of the force; and

determine a blood pressure of the user by an oscillometric technique based on the PPG data and the applied force.

12. The mobile device of claim 11, 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.

13. The mobile device of claim 11, wherein the IMU comprises an accelerometer and a gyroscope, and the IMU data comprises multi-axis accelerometer data and multi-axis gyroscope data.

14. 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's body part applying a force on a camera of the mobile device;

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

capturing, using the camera of the mobile device, photoplethysmography (PPG) data of a set of blood vessels in the body part concurrently with the application of the force; and

determining a blood pressure of the user using an oscillometric technique based on the PPG data and the applied force.

15. The one or more non-transitory computer-readable media of claim 14, 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, a configuration of the vibration motor, or a configuration of the camera.