mOralDataset: A dataset for inferring Oral Hygiene Behaviors in-the-wild using wrist-worn inertial sensors

Publication: mORAL: An mHealth Model for Inferring Oral Hygiene Behaviors in-the-wild Using Wrist-worn Inertial Sensors
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Summary

- Large scale: 3,886 hours of sensor data were collected over 290 days from 25 users.
- Everyday devices: sensors from smartphone and smartwatch.
- In-the-Wild: data was collected from users that were engaged in their regular natural behavior for continuously for more than 7 days for each user.
- Publicly available: everyone is invited to download the dataset for free and use it (conditioned on citing our original paper -- linked below).

This dataset was collected in 2017-2019 at the MD2K Center, University of Memphis:
- Sayma Akther
- Nazir Saleheen
- Shahin Samiei
- Dr. Vivek Shetty
- Dr. Emre Ertin
- Dr. Santosh Kumar

Dataset description

The dataset contains data from 25 participants (12 males, 13 females; mean age 28.5 ± 7.6 years), each identified with a random identifier, who completed one week-long brushing and flossing study.

Devices and Sensors

- MotionSense ("wristband") that included 3-axis accelerometers sampled at 16 Hz and 3-axis gyroscopes sampled at 32 Hz. Data were collected via wireless Bluetooth connection to a study smartphone platform.
- Samsung Galaxy S5 smartphone platform
- Bluetooth-enabled Oral-B toothbrush ("SmartBrush")
Data collection protocol

The study team conducted a field study to collect labeled sensor data in participants’ natural environments. The study was approved by the Institutional Review Board (IRB) and all participants provided written informed consent. At the time of recruitment, potential study participants were screened for their brushing habits (at least twice daily) and flossing habits (at least once daily). Once enrolled, participants wore the wristbands during their waking hours for seven (7) days. Participants were asked to use the study smartphone daily to record videos of themselves when performing their typical oral health routines (e.g., toothbrushing or flossing) in a comfortable setting (e.g., at home), while wearing the wristband. Non-identifiable sensor data was periodically uploaded from the smartphone platform via a dedicated HTTPS connection to a secure server.

Video data collection

The videos provided the ground truth labels for toothbrushing and flossing events. The phone stored these data on an encrypted microSD card. Video data were recovered from the phone at the end of the study period.

Annotation of Oral Hygiene Behaviors (OHB) from Video Data

To create labeled data for model development and evaluation, we annotated the video data to record the timing of each OHB. In total, 362 videos were collected, each with an average duration of 3.12 minutes. We annotated the brushing type (normal or SmartBrush), flossing type (string or pick), and their corresponding start/end times from the videos.

For brushing, special attention was paid to the interval between the lowering and raising of the brush-holding hand from the mouth. This interval was marked as a pause. We also marked the orientation configuration of both wrists, the brushing wrist (left or right), use of manual or SmartBrush, flossing with string or picks, flossing wrist (left or right), and video pause times.

Sensor data and annotation files

Accelerometer_Left_Wrist and Accelerometer_Right_Wrist

Example:

<table>
<thead>
<tr>
<th>timestamp</th>
<th>offset</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1505585435721</td>
<td>-21600000</td>
<td>0.001220703125</td>
<td>-0.0009765625</td>
<td>-1.03076171875</td>
</tr>
</tbody>
</table>

Column Details:
1. **timestamp (UTC)**: Coordinated Universal Time indicating the number of milliseconds since January 1, 1970 (Unix time)
   - Unit: milliseconds
   - Type: long

2. **offset**: The difference in time (shown in milliseconds) between the UTC timestamp and the local observed time
   - Unit: milliseconds
   - Type: long

3. **x**: Acceleration MotionSense accelerometer in the x-axis
   - Unit: g (G-forces)
   - Type: double
   - Sampling frequency: 16 Hz
   - Range: -2g to +2g

4. **y**: Same as above (accelerometer_x) on the y-axis

5. **z**: Same as above (accelerometer_x) on the z-axis

**Gyroscope_Left_Wrist and Gyroscope_Right_Wrist**

**Example:**

<table>
<thead>
<tr>
<th>timestamp</th>
<th>offset</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1505585435721</td>
<td>-21600000</td>
<td>47.30224609375</td>
<td>4.02069091796875</td>
<td>-17.7459716796875</td>
</tr>
</tbody>
</table>

**Column Details:**

1. **timestamp (UTC)**: Coordinated Universal Time indicating the number of milliseconds since January 1, 1970 (Unix time)
   - Unit: milliseconds
   - Type: long

2. **offset**: The difference in time between the UTC timestamp and the local observed time
   - Unit: milliseconds
   - Type: long

3. **x**: the rate at which the MotionSense device rotates around the x-axis
   - Unit: degree/second
   - Type: double
   - Sampling frequency: 32 Hz
   - Range: -250 to +250
4. **y:**
   - Same as above (gyroscope_x) around the y-axis

5. **z:**
   - Same as above (gyroscope_x) around the z-axis

**Annotation**

**Example:**

<table>
<thead>
<tr>
<th>start_timestamp (UTC)</th>
<th>offset</th>
<th>end_timestamp (UTC)</th>
<th>label</th>
<th>wrist</th>
<th>is_manual_brushing</th>
<th>is_smart_brushing</th>
<th>is_flossing</th>
<th>left_orientation</th>
<th>right_orientation</th>
<th>session</th>
</tr>
</thead>
<tbody>
<tr>
<td>1529044098000</td>
<td>-2160000</td>
<td>1529044215000</td>
<td>manual_brushing</td>
<td>Right</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**Column Details:**

1. **start_timestamp (UTC):** Timing of the first video frame when the participant began a defined activity (name of the activity is found in 'label' column)
   - Unit: milliseconds
   - Type: long

2. **offset:** The difference in time between UTC time and the local observed start time
   - Unit: milliseconds
   - Type: long

3. **end_timestamp (UTC):** Timing of the last video frame when the participant ends the activity
   - Unit: milliseconds
   - Type: long

4. **label:** name of the activity. Possible values (as defined in the paper):
   - Values
     - i. manual_brushing
     - ii. smart_brushing
     - iii. string_flossing
     - iv. pick_flossing
     - v. pause
   - Type: String

5. **wrist:** brushing or flossing wrist
   - Type: String
   - Values: Left, Right, or Both

6. **is_manual_brushing:** True/False
7. **is_oralb_brushing**: True/False
   - Type: Boolean

8. **is_flossing**: True/False
   - Type: Boolean

9. **left_orientation**: Orientation of the left wrist.
   - Type: int
   - values: 0, 1, 2, and 3 as defined in the paper.

10. **right_orientation**: Orientation of the right wrist.
    - Type: int
    - values: 0, 1, 2, and 3 as defined in the paper.

11. **session**: Serially assigned session id number for brushing or flossing sessions
    - Type: int
    - Values: 1, 2, 3, ...