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Audio Guidance to Enable Vision-Impaired Individuals to Move Independently

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Audio Guidance to Enable Vision-Impaired Individuals to Move Independently

ABSTRACT

At present, when an individual who is blind or has low-vision runs or walks for exercise, they might use a treadmill, rely on a guide dog, or use a tethered human guide. Independent and safe exercise, whether walking or running, is one way to increase personal agency and improve the quality of life for vision-impaired persons. This disclosure describes techniques that use on-device machine learning to enable a vision-impaired individual to independently walk or run, e.g., for exercise. A tape or guideline is painted along the running path. A mobile device camera detects the guideline. An app on the phone estimates the user's position to the left or to the right of the guideline. The app provides audio cues in stereo to direct the person to stay in close proximity to the guideline while walking or running.

KEYWORDS

- Vision impairment
- Vision loss
- Jogging
- Assistive technology
- Audio guidance
- Audio cues
- Directional guidance
- Computer vision
- Image segmentation
- On-device machine learning

BACKGROUND

Vision impairment increases the risk of mortality and morbidity, and can reduce the quality of life. This is primarily due to the lack of independence brought on by vision loss. Individuals with vision loss have to confront and navigate a widely inaccessible world. At present, when an individual who is blind or has low-vision runs or walks for exercise, they might use a treadmill, rely on a guide dog, or use a tethered human guide. Independent and safe exercise, whether walking or running, is one way to increase personal agency and improve the quality of life for persons who are blind or have low vision.

Some existing techniques to assist vision-impaired individuals to walk and to navigate include:

- Beacons installed at various locations throughout a city enable vision-impaired individuals to home into the location or business they seek by giving audio instructions via a smartphone app [1].
- Smartphone apps based on computer vision provide guidance to vision-impaired individuals at traffic intersections [2]. This technology, however, cannot be used for free walking or running.
- Ultrasound sensors can identify obstacles and other people [3, 4]. This technology, however, does not give directions or guidance.
- Position-location techniques, e.g., GPS, and inertial measurement units (IMU) can be used to create a virtual corridor within which a vision-impaired runner (or walker) can move safely [5]. Haptic feedback is provided to enable the vision-impaired runner to stay within the corridor. However, the GPS+IMU positioning accuracy is sometimes insufficient to keep the runner on a tight path. Because such techniques rely on GPS and not on visual information, these cannot be used indoors or in locations where GPS is unavailable.
- A variety of current techniques [6, 7] use computer vision to help vision-impaired individuals to read text and identify objects; however, these are incapable of guiding a person that is moving.

DESCRIPTION

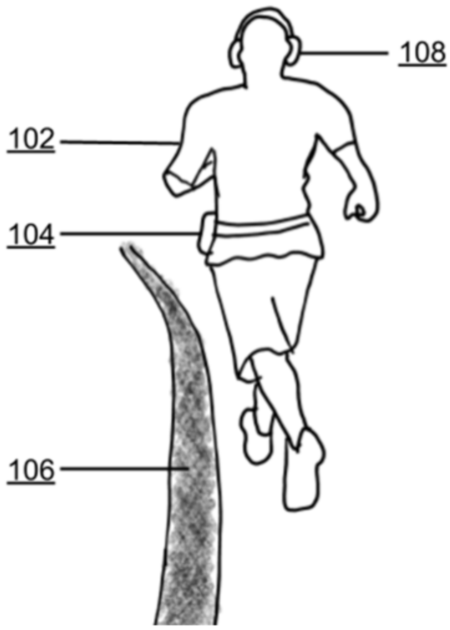

Fig. 1: Enabling vision-impaired individuals to move independently

This disclosure describes techniques that, with user permission, use on-device machine learning to enable a vision-impaired individual to independently walk or run, e.g., for exercise. As illustrated in Fig. 1, a tape or guideline (106) is painted along the path. A mobile device (104), e.g., a smartphone, is worn around the waist of the user (102) with a custom belt and harness. Headphones (108), e.g., of bone-conduction variety, connect to the mobile phone, e.g., using Bluetooth.

The mobile phone camera acts as a sensor to detect the guideline which is a line on the ground along a predetermined path. Using the guideline, an app on the phone estimates the user's position to the left or to the right of the guideline. The app on the mobile phone utilizes machine-learning models to estimate the user's position with reference to the guideline. The app runs fully on-device, and is usable without an internet connection.

The app provides audio cues (e.g., in stereo) to direct the person to stay in close proximity to the line while walking or running. If the person drifts to the left of the line, they hear an audio signal in their left ear that increases in volume and dissonance the further they drift to the left. As they navigate back to the line, the volume and dissonance decrease. On or near the line, the audio cue is low and just audible. As they drift to the right of the line, they hear an audio signal in their right ear that increases in volume and dissonance the further they drift to the right.

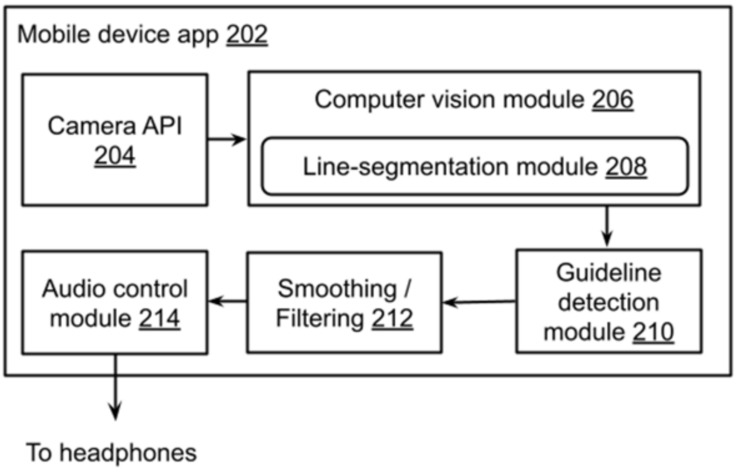

Fig. 2: Architecture to enable vision-impaired individuals to move independently

Fig. 2 illustrates an example architecture to enable vision-impaired individuals to move independently. A mobile device app (202) includes a camera application programming interface (API 204), which provides frames captured by the camera of the mobile device to a computer-vision module (206). The computer-vision module includes a line segmentation module (208), which uses one or more machine-learning models trained to detect lines on a surface, and can be implemented, e.g., on a digital signal processor.

The computer-vision module creates a masked image that selectively includes detected segments. A guideline detection module (210) accepts the masked image as input and detects the guideline. A smoothing/filtering module (212) uses a low-pass filter to eliminate spurious spikes and signals that may be caused by camera shake and running movements. An audio control module (214) renders guideline detection into a stereo signal to guide the runner, or to alert the runner if the guideline is lost. The stereo signals are sent to the headphones, e.g., via Bluetooth or other connection.

The on-device line segmentation model (208) takes frames from the camera of the mobile device as input and classifies each pixel in the frame into two classes, guideline and not-guideline. This simple confidence mask, applied to every frame, enables the app to determine where a runner is with respect to a line on the running path. Based on this determination and on the succeeding smoothing/filtering function, the app generates audio signals that help the runner orient and stay on the line, or that instruct the runner to stop if they veer too far away.

Simplifying the output of the segmentation module into two classes enables low latency and power consumption. The throughput can be increased by downsizing the input image prior to feeding it to the segmentation module. A further speed-up can be made possible by skipping the last up-sample layer of the machine-learning model and by directly outputting the predicted masks. Such output-dimension reduction can improve the runtime of the segmentation model and, by reducing the input resolution, can also speed up the downstream processing.

In this manner, by triggering self-corrective, real-time, audio feedback based on a runner's position in relation to a guideline, the described audio-navigation techniques give the user full agency. Provided with a safe and secure pathway with a pre-installed guideline, a person with visual impairment is able to walk or run independently without a cane, a guide dog, or a tethered partner runner. The techniques can also be used to guide robots.

CONCLUSION

This disclosure describes techniques that use on-device machine learning to enable a vision-impaired individual to independently walk or run, e.g., for exercise. A tape or guideline is painted along the running path. A mobile device camera detects the guideline. An app on the phone estimates the user's position to the left or to the right of the guideline. The app provides audio cues in stereo to direct the person to stay in close proximity to the guideline while walking or running.

REFERENCES

[1] https://www.foresightar.com/ accessed May 13, 2021.

[2] Murali, Vidya N., and James M. Coughlan. "Smartphone-based crosswalk detection and localization for visually impaired pedestrians." In *2013 IEEE International Conference on Multimedia and Expo Workshops (ICMEW)*, pp. 1-7. IEEE, 2013.

[3] https://strap.tech/product/ accessed May 13, 2021.

[4] https://imerciv.com/ accessed May 13, 2021.

[5] https://www.wear.works/ accessed May 13, 2021.

[6] Lookout by Google - Apps on Google Play accessed May 13, 2021.

[7] OrCam MyEye 2.0 - For People Who Are Blind or Visually Impaired https://www.orcam.com/en/myeye2/ accessed May 13, 2021.

[8] Rethinking Atrous Convolution for Semantic Image Segmentation, available online at https://arxiv.org/abs/1706.05587 accessed May 13, 2021.

[9] Searching for MobileNetV3, available online at https://arxiv.org/abs/1905.02244 accessed May 13, 2021.

[10] TensorFlow Lite | ML for Mobile and Edge Devices, available online at https://www.tensorflow.org/lite accessed May 13, 2021.

[11] Vision - ML Kit, available online at https://developers.google.com/ml-kit/vision accessed May 13, 2021.

[12] Jaccard index, available online at https://en.wikipedia.org/wiki/Jaccard_index accessed May 13, 2021.